Cloud Data Management Interface

Version 1.0

"This document has been released and approved by the SNIA. The SNIA believes that the ideas, methodologies, and technologies described in this document accurately represent the SNIA goals and are appropriate for widespread distribution. Suggestion for revision should be directed to http://www.snia.org/feedback/.

SNIA Technical Position

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Foreword

Abstract

This specification defines an interface for interoperable transfer and management of data in a cloud storage environment.

SNIA Web Site

Current SNIA practice is to make updates and other information available through their web site at http://www.snia.org

SNIA Address

Requests for interpretation, suggestions for improvement and addenda, or defect reports are welcome. They should be sent to the Storage Networking Industry Association, 425 Market Street, Suite #1020, San Francisco, CA 94105, U.S.A.

Acknowledgements

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Introduction

Purpose and Audience

This interface provides the means to access cloud storage and to manage the data stored there. The intended audience is application developers who are implementing or using cloud storage.

Organization

The chapter contents of this document are described as follows:

Chapter	Contents
1 - Scope	Defines the scope of this document
2 - References	Lists the documents referenced within this document
3 - Conventions	Describes the conventions used in presenting the interfaces and the typographical conventions used in this document
4 - Terms	Provides terminology used within this document
5 - Overview of Cloud Storage	Provides a brief overview of cloud storage and details the philosophy behind the standard as a model for the operations
6 - Getting Started	Gives an example of the resources that can be accessed and the representations used to modify them
7 - Interface Specification	Provides a description of HTTP status codes, CDMI object types, object references, and object manipulations
8 - Data Objects	Provides the normative specification for data objects
9 - Container Objects	Provides the normative specification of container objects
10 - Domain Objects	Provides the normative specification of domain objects
11 - Queue Objects	Provides the normative specification of queue objects
12 - Capability Objects	Provides the normative specification of capability objects
13 - Exported Protocols	Discusses how virtual machines in the cloud computing environment can use the exported protocols from CDMI containers
14 - Snapshots	Discusses how snapshots are accessed under CDMI containers
15 - Serialization/Deserialization	Discusses serialization and deserialization, including import and export of serialized data under CDMI
16 - Metadata	Provides the normative specification of the metadata used in the interface
17 - CDMI Logging	Describes CDMI functional logging for object functions, security events, and data management events
18 - Retention and Hold Management	Describes the optional retention management disciplines to be implemented into the system management functions
Annex A - Transport Security	Provides normative text for securing the HTTP communications protocol for transferring CDMI messages
Annex B - Extending the Interface	Provides informative guidelines for extending the interface

1 Scope

This interface provides the means to access cloud storage and to manage the data stored there. The intended audience is application developers who are implementing or using cloud storage.

2 References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[CRC] Williams, Ross, "A Painless Guide to CRC Error Detection Algorithms", Chapter 16, August 1993, http://www.repairfaq.org/filipg/LINK/F_crc_v3.html

[ISO-8601] International Standards Organization, "Data elements and interchange formats -- Information interchange -- Representation of dates and times", ISO 8601:20044 - http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40874

[ITU-T509] International Telecommunications Union Telecommunication Standardization Sector (ITU-T), Recommendation X.509: Information technology - Open Systems Interconnection - The Directory: Public-key and attribute certificate frameworks, May 2000. Specification and technical corrigenda - http://www.itu.int/ITU-T/publications/recs.html

[PKS12] RSA Laboratories, PKCS #12: Personal Information Exchange Syntax, Version 1.0, June 1999. Specification and Technical Corrigendum - http://www.rsa.com:80/rsalabs/node.asp?id=2138

[REST] "Representational State Transfer" - http://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm

[RESTful Web] Richardson, Leonard and Sam Ruby, RESTful Web Services, O'Reilly, 2007.

[RFC2119] IETF RFC 2119. Key words for use in RFCs to Indicate Requirement Levels - http://www.ietf.org/rfc/rfc2119.txt

[RFC2045] IETF RFC 2045. Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies - http://www.ietf.org/rfc/rfc2045.txt

[RFC2578] IETF RFC 2578. Structure of Management Information Version 2 (SMIv2) - http://www.ietf.org/rfc/rfc2578.txt

[RFC2616] IETF RFC 2616. Hypertext Transfer Protocol -- HTTP/1.1 - http://www.ietf.org/rfc/rfc2616.txt

[RFC3280] IETF RFC 3280. Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile - http://www.ietf.org/rfc/rfc3280.txt

[RFC3530] IETF RFC 3530. Network File System (NFS) version 4 Protocol - http://www.ietf.org/rfc/rfc3530.txt

[RFC3986] IETF RFC 3986. Uniform Resource Identifier (URI): Generic Syntax - http://www.ietf/org/rfc/rfc3986.txt

[RFC4346] IETF RFC 4346. The Transport Layer Security (TLS) Protocol Version 1.1 - http://tools.ietf.org/rfc/rfc4346.txt

[RFC4627] IETF RFC 4627. The application/json Media Type for JavaScript Object Notation (JSON) - http://www.ietf.org/rfc/rfc4627.txt

[RFC5246] IETF RFC 5246. The Transport Layer Security (TLS) Protocol Version 1.2 - http://tools.ietf.org/rfc/rfc5246.txt

[SIRDM] Storage Industry Resource Domain Model - http://www.snia.org/education/storage_networking_primer/sirdm/

3 Conventions

3.1 Interface Format

Each interface description has eight sections, as described in Table 1.

Table 1 – Interface Format Descriptions

Section	Description
Synopsis	The GET, PUT, and POST semantics
Capabilities	A description of the supported operations
Request Headers	The request headers, such as Accept, Authorization, Content-Length, Content-Type, X-Cloud-Client-Specification-Version
Request Message Body	A description of the message body contents
Response Headers	The response headers, such as Content-Length, Content-Type
Response Message Body	A description of the message body contents
Response Status	A list of codes
Example Request	An example of the operation

3.2 Typographical Conventions

The typographical conventions used in this document are described in Table 2.

Table 2 – Typographical Conventions

Convention	Description
`Fixed-width text`	The names of commands and on-screen computer output
`Bold, fixed-width text`	What you type, contrasted with on-screen computer output
Italicized text	Variables, field names, and book titles
Note:	Additional or useful informative text
WARNING:	Indicates that you should pay careful attention to the probable action, so that you may avoid system failure or harm.

4 Terms

For the purposes of this document, the following definitions apply.

4.1 Access Control List*

A persistent list, commonly composed of Access Control Entries (ACEs), that enumerates the rights of principals (users and groups of users) to access resources.

4.2 ACL*

Acronym for Access Control List.

4.3 CDMI

Acronym for Cloud Data Management Interface.

4.4 Object Identifier

A globally unique object identifier (OID) assigned at creation time for every object stored within a CDMI-compliant system.

4.5 Cloud Storage*

Synonym for Data Storage as a Service

4.6 CRC

Acronym for cyclic redundancy check.

4.7 CRUD

Acronym for Create, Retrieve, Update, and Delete

4.8 Data Storage as a Service*

Delivery over a network of appropriately configured virtual storage and related data services, based on a request for a given service level. Delivery of virtualized storage and data services on demand over a network.

Discussion: DaaS typically hides any limit to scalability, is either self-provisioned or provisionless, and is billed based on consumption.

4.9 DaaS*

Acronym for Data Storage as a Service

4.10 Domain*

A shared user authorization database that contains users, groups, and their security policies.

Each CDMI object belongs to a single domain, and each domain provides user mapping and accounting information.

4.11 Infrastructure as a Service*

Delivery over a network of an appropriately configured virtual computing environment, based on a request for a given service level. Delivery of a virtualized computer infrastructure on demand. Typically, IaaS is either self-provisioned or provisionless and is billed based on consumption.

4.12 iSCSI

Acronym for Internet Small Computer Systems Interface

4.13 IaaS*

Acronym for Infrastructure as a Service

4.14 LUN

Acronym for Logical Unit Number

4.15 MIME

Acronym for Multipurpose Internet Mail Extensions

4.16 NFS

Acronym for Network File System

4.17 Object

In CDMI, any entity that has an OID, a unique URI, and contains state. Types of CDMI objects include data objects, containers, capabilities, domains, and queues.

4.18 OCCI

Acronym for Open Cloud Computing Interface

4.19 OID

Acronym for object identifier

4.20 Platform as a Service*

Delivery over a network of a virtualized programming environment, consisting of an application deployment stack based on a virtual computing environment. Typically, PaaS is based on IaaS, is either self-provisioned or provisionless, and is billed based on consumption. Delivery of an application deployment stack on demand, based on a virtualized computer infrastructure.

4.21 Private Cloud*

Delivery of SaaS, PaaS, IaaS, and/or DaaS to a restricted set of customers, usually within a single organization. Private clouds are created due to issues of trust.

4.22 Public Cloud*

Delivery of SaaS, PaaS, IaaS, and/or DaaS to a relatively unrestricted set of customers

4.23 PaaS*

Acronym for Platform as a Service

4.24 Representational State Transfer*

A specific set of principles for defining, addressing and interacting with resources addressable by URIs.

Architectures that follow these principles are said to be RESTful. The principles include: abstraction of state into resources and a uniform set of representations and operations (e.g., HTTP verbs like GET and PUT as the only means to manipulate a resource). RESTful interfaces are contrasted with Web Services interfaces such as WBEM, which tend to be RPC-like.

4.25 REST*

Shorthand notation for Representational State Transfer

4.26 Software as a Service

Delivery over a network, on demand, of the use of an application. Delivery of an application on demand.

4.27 SaaS*

Acronym for Software as a Service

4.28 Uniform Ressource Identifier

A compact sequence of characters that identifies an abstract or physical resource.

4.29 URI

Acronym for Uniform Resource Identifier

4.30 XAM™

Acronym for eXtensible Access Method

4.31 XSet

The primary stored object abstraction in XAM.

4.32 XUID

Acronym for XSet Unique IDentifier

*Definitions taken from The SNIA Dictionary.

5 Overview of Cloud Storage

5.1 Introduction

When discussing cloud storage and standards, it is important to distinguish the various resources that are being offered as services. These resources are exposed to clients as functional interfaces (data paths) and are managed by management interfaces (control paths). We explore the various types of interfaces that are part of offerings today and show how they are related. We propose a model for the interfaces that can be mapped to the various offerings and that form the basis for rich cloud storage interfaces into the future.

Another important concept in this specification is that of metadata. When managing large amounts of data with differing requirements, metadata is a convenient mechanism to express those requirements in such a way that underlying data services can differentiate their treatment of the data to meet those requirements.

The appeal of cloud storage is due to some of the same attributes that define other cloud services: pay as you go, the illusion of infinite capacity (elasticity), and the simplicity of use/management. It is therefore important that any interface for cloud storage support these attributes, while allowing for a multitude of business cases and offerings, long into the future.

5.2 What is Cloud Storage?

The use of the term cloud in describing these new models arose from architecture drawings that typically used a cloud as the dominant networking icon. The cloud conceptually represents any-to-any connectivity in a network. The cloud also conceptually represents an abstraction of concerns, such that the actual connectivity and the services running in the network that accomplish that connectivity do so with little manual intervention.

This abstraction of complexity and promotion of simplicity is what primarily constitutes a cloud of resources, regardless of type. An important part of the cloud model, in general, is the concept of a pool of resources that is drawn from, on demand, in small increments (smaller than what you would typically purchase by buying equipment). The relatively recent innovation that has made this possible is virtualization.

Thus, cloud storage is simply the delivery of virtualized storage on demand. The formal term we propose for this is Data Storage as a Service (DaaS), which means "delivery over a network of appropriately configured virtual storage and related data services, based on a request for a given service level."

5.3 Data Storage as a Service

By abstracting data storage behind a set of service interfaces and delivering it on demand, a wide range of actual offerings and implementations are possible. The only type of storage that is excluded from this definition is that which is delivered, not based on demand, but on fixed capacity increments.

An important part of any DaaS offering is the support of legacy clients. Support is accommodated with existing standard protocols such as iSCSI (and others) for block and CIFS/NFS or WebDAV for file network storage, as shown in Figure 1, “Existing Data Storage Interface Standards”

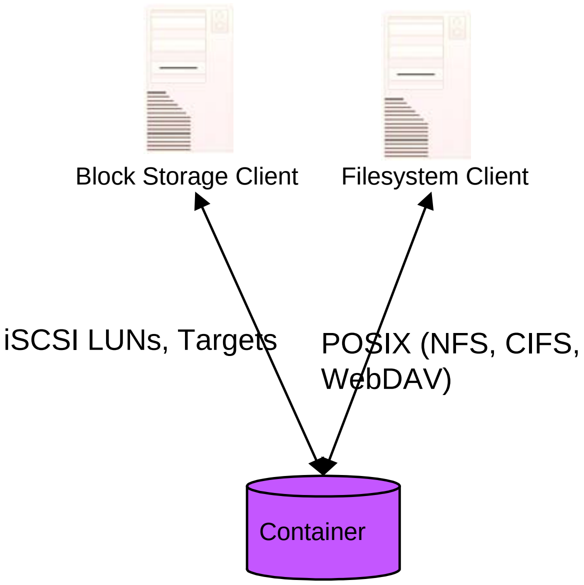


Figure 1 – Existing Data Storage Interface Standards

The difference between the purchase of a dedicated appliance and that of cloud storage is not the functional interface, but merely the fact that the storage is delivered on demand. The customer pays for either what they actually use, or in other cases, what they have allocated for use. In the case of block storage, a LUN, or virtual volume, is the granularity of allocation. For file protocols, a file system is the unit of granularity. In either case, the actual storage space can be thin provisioned and billed for, based on actual usage. Data services, such as compression and deduplication, can be used to further reduce the actual space consumed.

Managing this storage is typically done out of band of these standard data storage interfaces, either through an API, or more commonly, through an administrative browser-based user interface. This interface may be used to invoke other data services as well, such as snapshot and cloning.

In this model, we abstract the underlying storage space exposed by these interfaces using the notion of a container. A container is not only a useful abstraction for storage space, but also serves as a grouping of the data stored in it and a point of control for applying data services in the aggregate.

Another type of DaaS offering is one of simple table space storage, allowing for horizontal scaling of database-like operations that certain applications need. Rather than virtualizing relational database instances, table space storage offers a new data storage interface of limited functionality, with the emphasis on scalability rather than features. Scalability allows the tables to be partitioned across multiple nodes based on common key values, affording horizontal scalability at the expense of functions that can typically only be implemented by a vertically-scaled relational database.

A great deal of innovation and change is happening in these interfaces, and each offering has its own unique proprietary interface, as shown in Figure 2, “Storage Interfaces for Database/Table Data”.

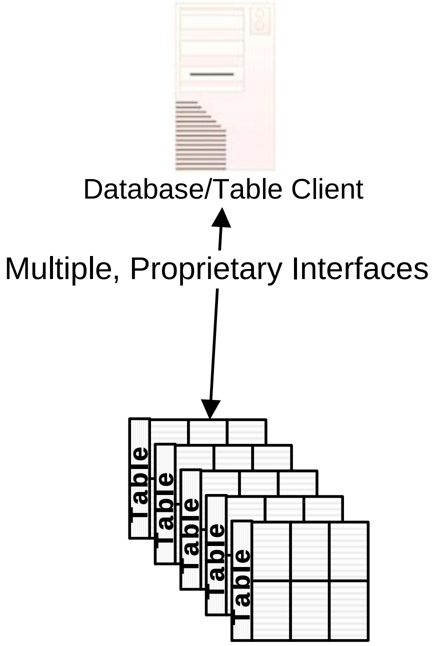


Figure 2 – Storage Interfaces for Database/Table Data

Due to the rapid innovation in this space, it is probably best to wait for further development of this type of cloud storage before trying to standardize a functional interface for this type of storage.

A third category of functional interface for data storage has emerged. This type of interface treats every data object as accessible via a unique URI. It can then be fetched using the standard HTTP protocol, and a browser can be used to invoke the appropriate application to deal with the data.

Each data object is created, retrieved, updated, and deleted (CRUD semantics) as a separate resource. In this type of interface, a container, if used, is a simple grouping of data objects for convenience. Nothing prevents the concept of containers, in this case, from being hierarchical, although any given implementation might support only a single level of such. We call this type of container a "soft" container, as shown in Figure 3, “Storage Interfaces for Object Storage Client Data”.

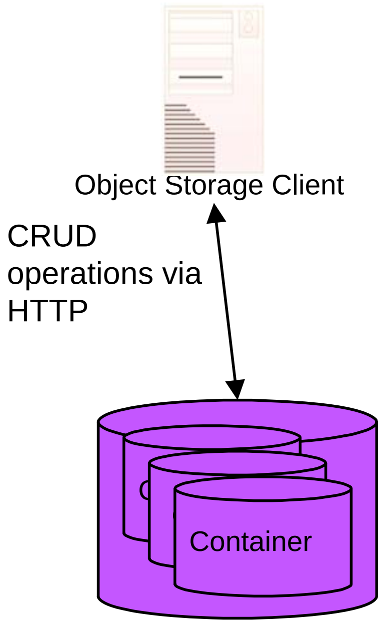


Figure 3 – Storage Interfaces for Object Storage Client Data

While there are several proprietary examples of this type of interface, they all pretty much support the same set of operations. This, then, is an area ripe for standardization.

5.4 Data Management in the Cloud

Many of the initial offerings of cloud storage focused on a kind of "best effort" quality of storage service, with very little offering of additional data services for that data. To address the needs of enterprise applications with cloud storage, however, there is increasing pressure to offer better quality of service and the deployment of additional data services.

The danger, of course, is that cloud storage loses its benefit of simplicity and the abstraction of complexity, as additional data services are applied and the implication that these services need to be managed. One can hardly have cloud storage customers setting up backup schedules through dedicated user interfaces, deploying data services individually for their data elements, and so on.

Fortunately, the SNIA Storage Industry Resource Domain Model (see Figure 4) [SIRDM] gives us a way to minimize this complexity and address the need for cloud storage to remain simple. By using the different types of metadata discussed in that model for a cloud storage interface, we can create an interface that allows offerings to meet the requirements of the data without adding undo complexity to the management of that data.

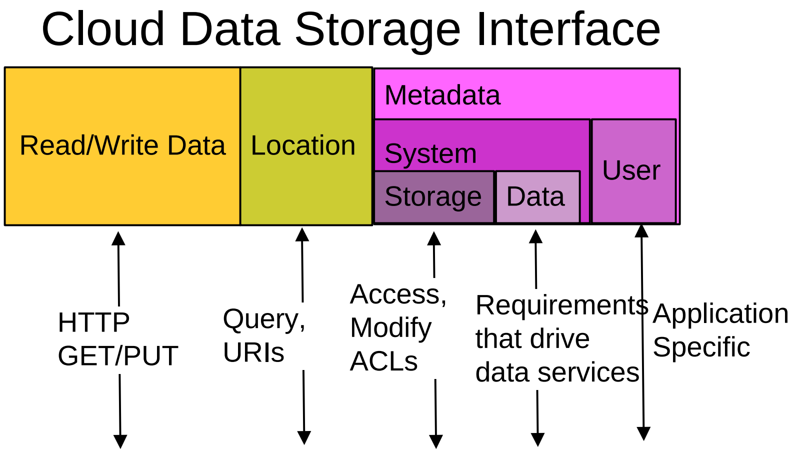


Figure 4 – Using the Resource Domain Model

By supporting metadata in a cloud storage interface standard and prescribing how the storage system and data system metadata is interpreted to meet the requirements of the data, we can retain the simplicity required by the cloud storage paradigm and still address the requirements of enterprise applications and their data.

User metadata is retained by the cloud and can be used to find the data objects and containers by doing a query for specific metadata values. The schema for this metadata can be determined by each application, domain, or the user. For more information on support for user metadata, see Section 16.2.

Storage system metadata is produced and interpreted by the cloud offering or basic storage functions, such as modification and access statistics, and for governing access control. For more information on support for storage system metadata, see Chapter 16, “Metadata”.

Data system metadata is interpreted by the cloud offering as data requirements that drive the operation of underlying data services for that data. It can apply to an aggregation of data objects in a container or even to individual data objects, if the offering supports this level of granularity. For more information on support for data system metadata, see Section 16.4.

5.5 Data and Container Management

There is no reason that managing data and managing containers should involve different paradigms. Therefore, we propose that the use of metadata be extended from applying to individual data elements to applying to containers of data as well. Thus, any data placed into a container essentially inherits the data system metadata of the container into which it was placed. When creating a new container within an existing container, the new container would similarly inherit the metadata settings of its parent's data system. Of course, the data system metadata can be overridden at the container or individual data element level, as desired.

Even if the functional interface that the offering provides does not support setting this type of metadata on individual data elements, it can still be applied to the containers, even though it may not be able to be overridden on the basis of individual data elements through that interface. For file-based interfaces that support extended attributes (i.e., CIFS, NFSv4), these extended attributes could be used to specify the data system metadata to override that specified for the container through these existing standard interfaces. The mapping of extended attribute names and values to individual file data requirements as supported by cloud storage will be done as a follow-on effort.

5.6 Reference Model for Cloud Storage Interfaces

By putting all of these elements together, we have the model, as shown in Figure 5, “Cloud Storage Reference Model”:

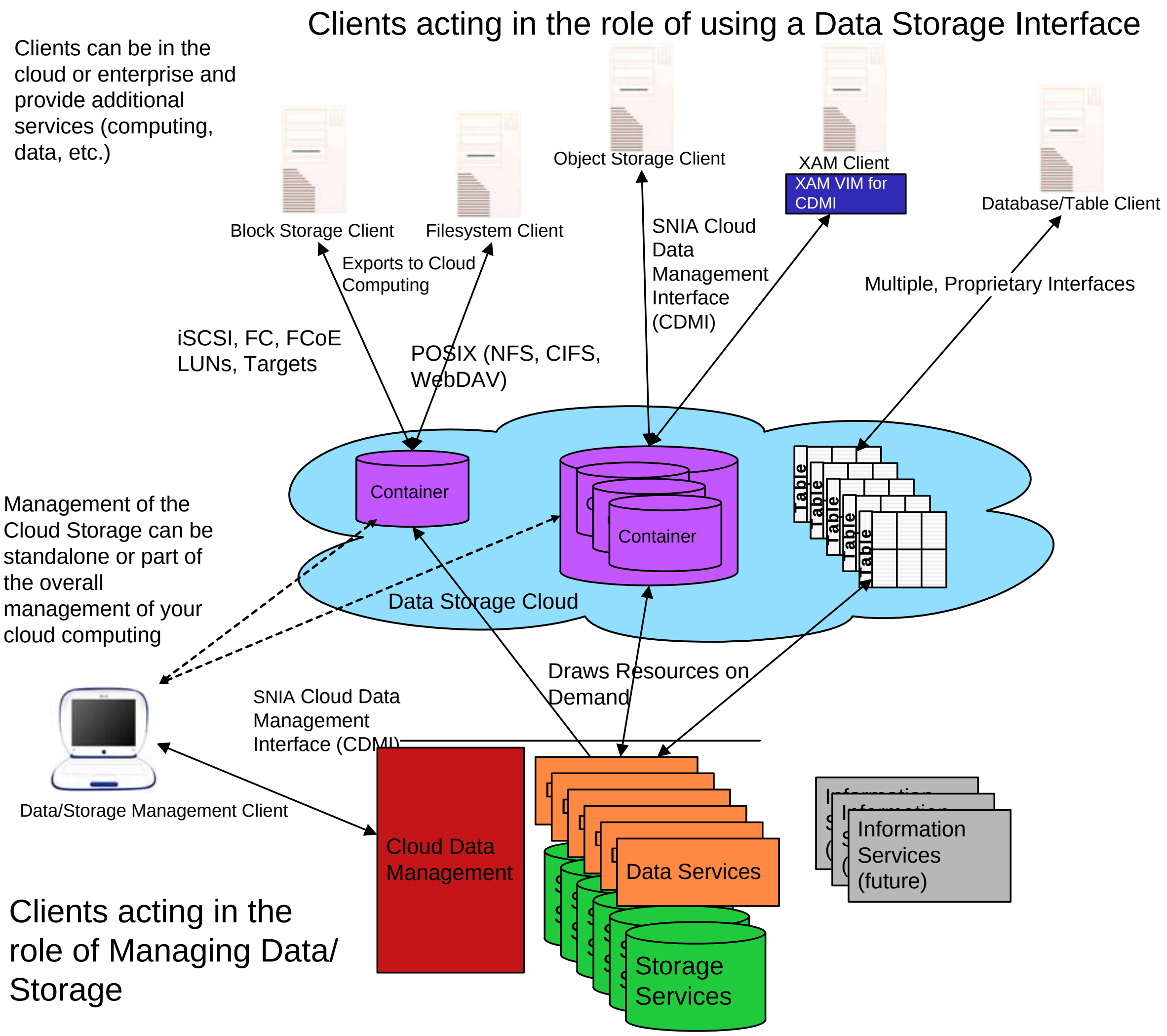

Clients acting in the role of using a Data Storage Interface
Clients can be in the cloud or enterprise and provide additional services (computing, data, etc.)
Block Storage Client
Filesystem Client
Object Storage Client
XAM Client
XAM VIM for CDMI
Database/Table Client
Exports to Cloud Computing
SNIA Cloud Data Management Interface (CDMI)
Multiple, Proprietary Interfaces
iSCSI, FC, FCoE LUNs, Targets
POSIX (NFS, CIFS, WebDAV)
Container
Container
Table
Data Storage Cloud
Management of the Cloud Storage can be standalone or part of the overall management of your cloud computing
Draws Resources on Demand
SNIA Cloud Data Management Interface (CDMI)
Data/Storage Management Client
Cloud Data Management
Data Services
Information Services (future)
Storage Services
Clients acting in the role of Managing Data/ Storage

Figure 5 – Cloud Storage Reference Model

This model shows multiple types of cloud data storage interfaces that are able to support both legacy and new applications. All of the interfaces allow storage to be provided on demand, drawn from a pool of resources. The capacity is drawn from a pool of storage capacity provided by storage services. The data services are applied to individual data elements, as determined by the data system metadata. Metadata specifies the data requirements on the basis of individual data elements or on groups of data elements (containers).

5.7 SNIA Cloud Data Management Interface

As shown in Figure 5, “Cloud Storage Reference Model”, the SNIA Cloud Data Management Interface (CDMI) is the functional interface that applications may use to create, retrieve, update, and delete data elements from the cloud. As part of this interface, the client will be able to discover the capabilities of the cloud storage offering and to use this interface to manage containers and the data that is placed in them. In addition, data system metadata can be set on containers and their contained data elements through this interface.

The majority of existing cloud storage offerings today will likely be able to implement the interface. They can implement the interface with an adapter to their existing proprietary interface, or they can implement the interface directly, side by side with their existing interfaces. In addition, existing client libraries, such as XAM™, can be adapted to this interface, as shown in Figure 5.

This interface may also be used by administrative and management applications to manage containers, domains, security access, and monitoring/billing information, even for storage that is functionally accessible by legacy or proprietary protocols. The capabilities of the underlying storage and data services are exposed so that clients can understand the offering.

Conformant cloud offerings may offer a subset of the CDMI interface, as long as they expose the limitations in the capabilities part of the interface.

The CDMI specification uses RESTful principles in the interface design where possible. In cases where we do not follow these principles, we explicitly call those out. For more information on the REST principles, please see [RESTful Web].

5.8 Object Model for CDMI

The model behind the Cloud Data Management Interface is shown in Figure 6, “CDMI Interface Model”.

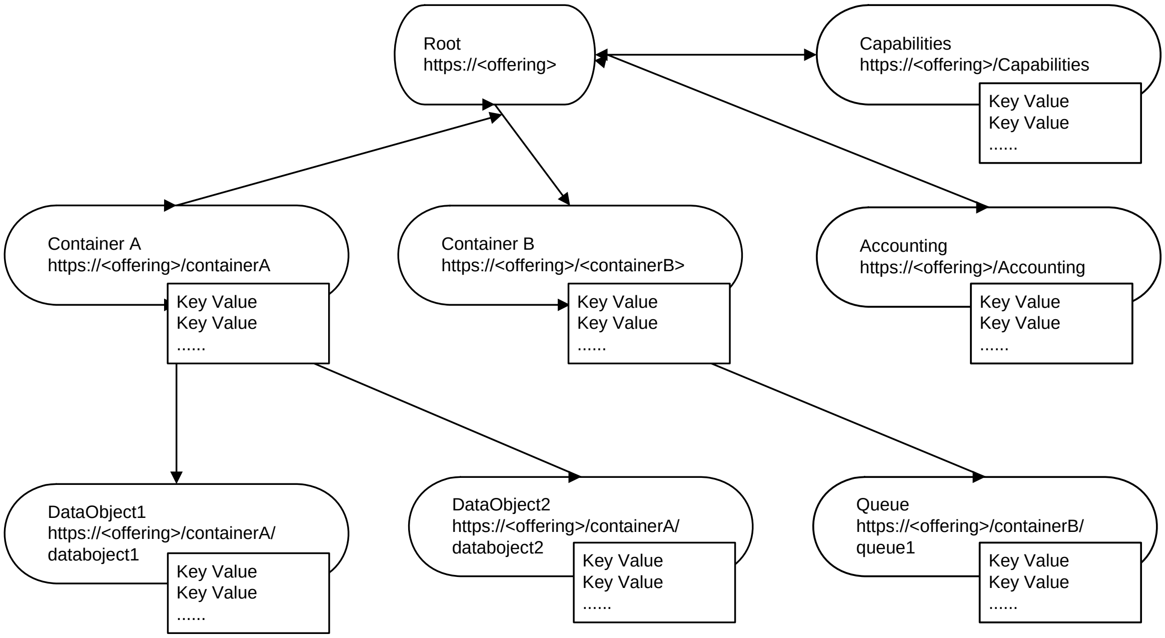


Figure 6 – CDMI Interface Model

For data storage operations, the client of the interface only needs to know about container objects and data objects. All data path implementations are required to support at least one level of containers, a sort of grouping of data objects. As shown in Figure 6, the client may do a PUT to the container URI and create a new container with the specified name. The KEY/VALUE metadata is optional. Once a container is created, a client may do a PUT to create a data object URI. A subsequent GET will fetch the actual data object and its value. The only metadata KEY/VALUE required on the data object PUT is content type (MIME). Other KEY/VALUE pairs can be used to specify the data requirements at the object level. This metadata is defined in the CDMI specification.

CDMI also defines an object, called a queue, which has special properties for in-order, first in, first-out creation and fetching of queue objects, similar to a container of data objects. More information on queues can be found in Chapter 11, “Queue Objects”.

The CDMI does not need to be used as the data path, and it applies to cloud storage that is exposed as either standard or proprietary interfaces. In this case, the client might stop at creating the container. The metadata is also used to configure the data requirements of the storage under the exported protocol that the container exposes, such as a block protocol or a file protocol. While many implementations may use an underlying file to store data for a block protocol (such as iSCSI), in the CDMI interface, the container is used as the abstraction for applying the data system metadata for this data and for attaching the structures that govern the exported protocols. This maps to the concept of a block storage location (Target, LUN) being a container of data objects, each a block in size and located by their Logical Block Address.

A cloud offering can also support domains, which allow administrative ownership to be associated with stored objects. Domains allow the specification of how user credentials are mapped to principles used in ACLs, allow granting of special cloud-related privileges, and allow delegation to external user authorization systems, such as LDAP or Active Directory. Domains can also be hierarchical, allowing for corporate domains with multiple children domains for departments or individuals. The domain concept is also used to aggregate usage data that is used to bill, meter, and monitor cloud use.

Finally, a capabilities resource and associated URI allows a client to discover the capabilities of the offering and its implementation of CDMI. The interface requires this resource, but static pages that list exactly what is implemented can satisfy this requirement.

5.9 CDMI Metadata

CDMI uses many different types of metadata, including HTTP metadata, data system metadata, user metadata, and storage system metadata.

HTTP metadata is metadata that is related to the use of the HTTP protocol, such as content-size, content-type, etc. This type of metadata is not specifically related to the CDMI standard, but needs to be discussed to explain how CDMI uses the HTTP standard.

Data system metadata is metadata that is specified by a CDMI client and attached to a container or data object, abstractly specifying the data requirements that are then supplied by data services that are deployed in the cloud storage system. The data system metadata settings are treated as goals. In some cases, actual measurements toward these goals are specified.

User metadata is arbitrarily-defined metadata that is specified by the CDMI client and attached to objects. The namespace used for user metadata is self-administered (such as using the reverse domain name) and restricted to not beginning with the prefix "cdmi_".

Storage system metadata is read-only metadata that is generated by the storage services in the system to provide useful information to a CDMI client. Examples include ACLs, creation time, etc.

	Created by User	**Created By System**
Consumed by User	User metadata	Storage system metadata
Consumed by System	Data system metadata	N/A

5.10 Object ID

Every object stored within a CDMI-compliant system will have a globally unique object identifier (Object ID) assigned at creation time. The CDMI object ID is a string but has rules for how it is generated and how it obtains its uniqueness. Each offering that implements CDMI is able to produce these identifiers without conflicting with other offerings.

Every CDMI system shall allow access to stored objects, by object ID, by allowing the object ID to be appended to the root container URI. For example, for the following root container URI, the second URI would provide access to objects by object ID:

```
http://cloud.example.com/root
http://cloud.example.com/root/cdmi_objectid/<objectID>
```

5.11 CDMI Object ID Format

The offering shall create the Object ID, which identifies an object. The Object ID shall be globally unique and shall conform to the format defined in Figure 7, “Object ID Format”. The native format of a Object ID is a variable-length byte sequence and shall be a maximum length of 40 bytes. An application should treat Object IDs as opaque byte strings. However, the Object ID format is defined such that its integrity can be validated, and independent offerings can assign unique Object ID values independently.

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**…**	**38**	**39**
Reserved (zero)	Enterprise Number			Reserved (zero)	Length	CRC		Opaque Data					

Figure 7 – Object ID Format

As shown in Figure 7,

- The reserved bytes shall be set to zero.
- The Enterprise Number field shall be the SNMP enterprise number of the offering organization that created the Object ID, in network byte order. See [RFC2578] and http://www.iana.org/assignments/enterprise-numbers. 0 is a reserved value.
- The 5th byte shall contain the full length of the Object ID, in bytes.
- The CRC field shall contain a 2-byte (16-bit) CRC in network byte order. The CRC field enables the Object ID to be validated for integrity. The CRC field shall be generated by running the

algorithm [CRC] across all bytes of the Object ID, as defined by the length field, with the CRC field set to zero. The CRC function shall have the following parameters:

— Name : "CRC-16"

— Width : 16

— Poly : 0x8005

— Init : 0x0000

— RefIn : True

— RefOut : True

— XorOut : 0x0000

— Check : 0xBB3D

This function defines a 16-bit CRC with polynomial 0x8005, reflected input, and reflected output. This CRC-16 is specified in [CRC].

- Opaque data in each Object ID shall be unique for a given Enterprise Number.
- The native format for a Object ID is binary. When necessary, Object ID textual representation should be base64-encoded, as described in Section 6.8 of [RFC2045], which uses US ASCII.

5.12 Security

- Security, in the context of CDMI, refers to the protective measures employed in managing and accessing data and storage. The specific objectives to be addressed by security include:
- Provide a mechanism that assures that the communications between a CDMI client and server cannot be read or modified by a third party
- Provide a mechanism that allows CDMI clients and servers to provide an assurance of their identity
- Provide a mechanism that allows control of the actions a CDMI client is permitted to perform on a CDMI server
- Provide a mechanism for records to be generated for actions performed by a CDMI client on a CDMI server
- Provide mechanisms to protect data at rest
- Provide a mechanism to eliminate data in a controlled manner
- Provide mechanisms to discover the security capabilities of a particular implementation

Security measures within CDMI can be summarized as transport security, user and entity authentication, authorization and access controls, data integrity, data and media sanitization, data retention, protections against malware, data at-rest encryption, and security capability queries. With the exception of both the transport security and the security capability queries, which are mandatory to implement, the security measures can vary significantly from implementation to implementation.

When security is a concern, the CDMI client should begin with a series of security capability queries (see Section 12.1.1, “Cloud Storage System-Wide Capabilities”) to determine the exact nature of the security features that are available. Based on responses from the CDMI implementation, a risk-based decision should be made as to whether the CDMI resource should be used. This is particularly true when the data to be stored in the cloud storage is sensitive or regulated, such that it must be protected (for example, encrypted) or handled in a particular manner (for example, full accountability and traceability of management and access).

HTTP is the mandatory transport mechanism for this version of CDMI, and HTTP over TLS (HTTPS) is the mechanism used to secure the communications between CDMI entities. To ensure both security and interoperability, all CDMI implementations are required to implement the Transport Layer Security (TLS) protocol as described in Annex A, but its use by CDMI entities is optional.

Additional details associated with the security capabilities are found in other sections of this document.

6 Common Operations

The example transactions in this chapter illustrate some of the more common CDMI operations.

6.1 Discover the Capabilities of a Cloud Storage Provider

Perform a GET to the capabilities URI:

```
GET /cdmi_capabilities/ HTTP/1.1
Host: cloud.example.com
Content-Type: application/vnd.org.snia.cdmi.capabilitiesobject+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.capabilities+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/cdmi_capabilities/",
    "objectID" : "AABwbQAQWTYZDTZq2T2aEw==",
    "parentURI" : "/",
    "capabilities" : {
        "cdmi_domains" : "true",
        "cdmi_export_nfs" : "true",
        "cdmi_export_webdav" : "true",
        "cdmi_export_iscsi" : "true",
        "cdmi_queues" : "true",
        "cdmi_notification" : "true",
        "cdmi_query" : "true",
        "cdmi_metadata_maxsize" : "4096",
        "cdmi_metadata_maxitems" : "1024",
        "cdmi_size" : "true",
        "cdmi_list_children" : "true",
        "cdmi_read_metadata" : "true",
        "cdmi_modify_metadata" : "true",
        "cdmi_create_container" : "true",
        "cdmi_delete_container" : "true"
    },
    "childrenrange" : "0-3",
    "children" : [
        "domain/",
        "container/",
        "dataobject/",
        "queue/"
    ]
}
```

6.2 Create a New Container

Perform a PUT to the new container URI:

```
PUT /MyContainer HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.container+json
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "metadata" : {

    }
}
```

The response looks like:

```
HTTP/1.1 201 Created
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/",
    "objectID" : "AABwbQAQ7EacyeWGVRGqCA==",
    "parentURI" : "/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/Container/",
    "completionStatus" : "Complete",
    "metadata" : {
        "cdmi_size" : "0"
    },
    "childrenrange" : "0-0",
    "children" : [

    ]
}
```

6.3 Create a Data Object in a Container

Perform a PUT to the new data object URI:

```
PUT /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "mimetype" : "text/plain",
    "metadata" : {

    },
    "value" : "Hello CDMI World!"
}
```

The response looks like:

```
HTTP/1.1 201 Created
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/MyDataObject.txt",
    "objectID" : "AABwbQAQb/ENV52Ai8a3MA==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/DataObject/",
    "completionStatus" : "Complete",
    "mimetype" : "text/plain",
    "metadata" : {

    },
    "cdmi_size" : "17"
}
```

6.4 List the Contents of a Container

Perform a GET to the container URI:

```
GET /MyContainer HTTP/1.1
Host: cloud.example.com
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/",
    "objectID" : "AABwbQAQ7EacyeWGVRGqCA==",
    "parentURI" : "/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/Container/",
    "percentageComplete" : "Complete",
    "metadata" : {

    },
    "childrenrange" : "0-1",
    "children" : [
        "MyDataObject.txt"
    ]
}
```

6.5 Read the Contents of a Data Object

GET from the data object URI:

```
GET /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/MyDataObject.txt",
    "objectID" : "AABwbQAQb/ENV52Ai8a3MA==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/DataObject/",
    "percentComplete" : "Complete",
    "mimetype" : "text/plain",
    "metadata" : {
        "cdmi_size" : "17"
    },
    "valuerange" : "0-17",
    "value" : "Hello CDMI World!"
}
```

6.6 Read Only the Value of a Data Object

Perform a GET to the data object URI:

```
GET /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: text/plain
Hello CDMI World!
```

6.7 Delete a Data Object

GET from the root URI:

```
DELETE /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
```

7 Interface Specification

7.1 HTTP Status Codes

HTTP status codes are used to convey the results of the RESTful operations and to follow the basic semantics of HTTP with minimal overloading, as described in each operation description below (see Table 3). Other status codes are not part of this specification and retain their original semantics from HTTP 1.1.

Table 3 – HTTP Status Codes

Status Code	HTTP Name	Used for
200	OK	Resource retrieved successfully
201	Created	Resource created successfully
202	Accepted	Long running operation accepted for processing
204	No Content	Operation successful, no data
400	Bad Request	Missing or invalid request contents
401	Unauthorized	Invalid authentication/authorization credentials
403	Forbidden	This user is not allowed to perform this request
404	Not Found	Requested resource not found
405	Method Not Allowed	Requested HTTP verb not allowed on this resource
406	Not Acceptable	No content type can be produced at this URI that matches the request
409	Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.
500	Internal Server Error	An unexpected vendor specific error
501	Not Implemented	A CDMI operation or metadata value was attempted that is not implemented.

7.2 Types of Objects in the Model

The five types of resource objects in the model include container objects, data objects, queue objects, domain objects, and capability objects (see Table 4). The Content-Type in any given operation is specific to each type of resource object.

Table 4 – Types of Objects in the Model

Object Type	Description
Container objects	Container objects may have child objects but have no value. Container objects may be exported via protocols other than CDMI for data path operations, but the associated value is not represented in container objects via the CDMI data path.
Data objects	Data objects have a value but have no children.
Queue objects	Queue objects have a value but have no children.

Table 4 – Types of Objects in the Model

Object Type	Description
Domain objects	Domain objects may have child objects but have no value.
Capability objects	Capability objects may have child objects but have no value.

The HTTP verbs overloaded by CDMI for each of these objects varies by object type. Non-overloaded HTTP operations may also be allowed for certain objects.

7.3 Object References

Object references are URIs within the cloud storage namespace that point to another URI within the same or another cloud storage namespace. References are similar to soft links in a file system, and the cloud does not guarantee that the referenced URI will be valid after the time of creation.

References are visible as children in a container and appear identical to non-referenced objects. Performing an operation (with the exception of create or delete) to a reference URI will result in a 302 Found HTTP redirect, with the "Location" HTTP header containing the redirect destination URI, which was specified at the time the reference was created. The reference’s destination URI cannot be altered once a reference has been created.

To continue, when CDMI clients receive a 302 Found redirect, they should retry the operation on the URI contained with the "Location" header.

A delete operation on a reference URI shall delete the reference.

8 Data Objects

8.1 Overview

Data objects are the fundamental storage component within CDMI and are analogous to files within a filesystem. Each data object has a set of well-defined fields that include a single data stream and standardized and optional metadata that is generated by the cloud storage system and specified by the cloud user.

Data objects are addressed in CDMI in one of the two following ways:

- `http://cloud.example.com/dataobject`
- `http://cloud.example.com/cdmi_objectid/AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==`

The first example addresses the data object by URI, and the second addresses the data object by object ID. Every data object has a single, globally-unique object identifier that remains constant for the life of the object. Each data object may also have one or more URI addresses that allow the object to be accessed.

Every data object has a parent object from which the data object inherits data system metadata that is not explicitly specified in the data object itself. For example, the "budget.xls" data object stored at "http://cloud.example.com/finance/budget.xls" would inherit data system metadata from its parent container, "finance".

Individual fields within a data object can be accessed by specifying the field name after a question mark "?" that is appended to the end of the data object URI. For example, the following URI would return just the value field in the response body:

```
http://cloud.example.com/dataobject?value
```

Specific ranges of the value field can be accessed by specifying a byte range after the value field name. For example, the following URI would return the first thousand bytes of the value field:

```
http://cloud.example.com/dataobject?value:0-1000
```

Byte ranges are specified as per Section 14.35.1 of RFC2616.

A list of unique fields, separated by a semicolon ";" can be specified, allowing multiple fields to be accessed in a single request. For example, the following URI would return the value and metadata fields in the response body:

```
http://cloud.example.com/dataobject?value;metadata
```

8.1.1 Data Object Metadata

Data object metadata can also include arbitrary user-supplied metadata and data system metadata, as specified in Chapter 16, “Metadata”.

8.1.2 Data Object Addressing

Each data object is addressed via at least one unique URI. A data object may be accessible via multiple virtual hosting paths, where, for example, "http://cloud.example.com/users/snia/cdmi/cdmi_specification.pdf" is also accessible through "http://snia.example.com/cdmi/cdmi_specification.pdf".

Multiple virtual hosting paths are outside the scope of this specification.

8.1.3 Data Object Consistency

Writing to a data object is an atomic operation. If a client were to read an object simultaneously with a write to that same object, it shall get either the old version or the new version, but not a mix of both. Writes are also atomic in the face of errors. Multiple simultaneous writes that complete without errors shall be ordered by the timestamps on the returning responses, which is to say, by the timestamps placed on the responses by the server-side implementation (i.e., according to the principle of eventual consistency).

Reading from an uninitialized data object byte shall return zero. If a client performs a data object value read from a specific byte range that has not previously been written to, the byte value returned shall be zero.

Note: Conformant implementations only need to support this atomicity via the CDMI object interface and are free to provide other semantics through other interfaces to the data in the container.

8.1.4 Data Object Representations

The representations in this section are shown using JSON notation. A conforming implementation shall support the mandatory parameters and may support the optional parameters. The parameter fields may be specified or returned in any order. Both clients and servers shall support JSON representation.

8.2 Create a Data Object (CDMI Content Type)

Synopsis:

Creates a new data object at the specified URI.

```
PUT <root URI>/<ContainerName>/<DataObjectName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers that already exist.
- <DataObjectName> is the name specified for the data object to be created.

Once created, the object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Delayed Completion of Create. On a create operation for a data object, the server may return a response of `202 Accepted`. In this case, the object is in the process of being created. This response is particularly useful for long-running operations, for instance, copying a large data object from a source URI. Such a response has the following implications:

- The server returns an object identifier along with the `202 Accepted.`
- With `202 Accepted`, the server implies that the following checks have passed:
  - User authorization for creating the object
  - User authorization for read access to any source object for move, copy, serialize, or deserialize
  - Availability of space to create the object or at least enough space to create a URI to report an error
- Future accesses to the URI created (or the object ID) will succeed modulo any delays due to use of eventual consistency.

The client performs GET operations to the URI to track the progress of the operation. In particular, the server returns two fields in its response body to indicate progress:

- A mandatory completionStatus text field contains either `Processing`, `Complete`, or an error message
- An optional percentComplete field that indicates the percentage to which the last PUT has completed (0 to 100).

GET does not return any value for the object when completionStatus is not `Complete`. When the final result of the create operation is an error, the URI is created with the completionStatus field set to the error message. It is the client's responsibility to delete the URI after the error has been noted.

Capabilities:

The following capabilities describe the supported operations that can be performed when creating a new data object:

- Support for the ability to create a new data object is indicated by the presence of the "cdmi_create_dataobject" capability in the parent container.
- If the new data object is a reference of an existing data object, support for the ability to create the reference is indicated by the presence of the "cdmi_create_reference" capability in the parent container.
- If the new data object is a copy of an existing data object, support for the ability to copy is indicated by the presence of the "cdmi_create_copy" capability in the parent container.
- If the new data object is the destination of a move, support for the ability to move the data object is indicated by the presence of the "cdmi_create_move" capability in the parent container.
- If the new data object is the destination of a deserialize operation, support for the ability to deserialize the source data object is indicated by the presence of the "cdmi_deserialize_dataobject" capability in the parent container.
- If the new data object is the destination of a serialize operation, support for the ability to serialize the source data object is indicated by the presence of the "cdmi_serialize_dataobject", "cdmi_serialize_container", "cdmi_serialize_domain", or "cdmi_serialize_queue" capability in the parent container.

Request Headers:

Header	**Type**	**Value**	**Mandatory/Optional**
Accept	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Header	Type	Value	Mandatory/Optional
X-CDMI-NoClobber	Header String	"true". Do not overwrite an existing object. If this header element is present and set to "true", it is an error for this operation to proceed. An update should be done instead.	Optional
X-CDMI-Partial	Header String	"true". Indicates that the newly created object is part of a series of writes, and has not yet been fully created. When set, the "completionStatus" field will be set to "Processing".	Optional

Request Message Body:

Name	Type	Description	Mandatory/Optional
mimetype	JSON String	Mime type of the data contained within the value field of the data object. This field shall not be included when deserializing, serializing, copying, moving, or referencing a data object. If this field is not specified, the value of "text/plain" will be assigned as the field value.	Optional
metadata	JSON Object	Metadata for the data object. • If this field is included when deserializing, serializing, copying, or moving a data object, the value provided shall replace the metadata from the source URI. • This field shall not be included when referencing a data object. • If this field is not specified, an empty JSON object ("{}") will be assigned as the field value.	Optional
domainURI	JSON String	URI of the owning domain. • If different from the parent domain, the user must have the "cross_domain" privilege. • If not specified, the parent domain will be used.	Optional
deserialize	JSON String	URI of a serialized CDMI data object that will be deserialized to create the new data object.	Optional*
serialize	JSON String	URI of a CDMI object that will be serialized into the new data object.	Optional*
copy	JSON String	URI of a CDMI data object or queue that will be copied into the new data object.	Optional*
move	JSON String	URI of a CDMI data object or queue that will be copied into the new data object, then removing the data object or queue value at the source URI upon the successful completion of the copy.	Optional*

Name	Type	Description	Mandatory/Optional
reference	JSON String	URI of a CDMI data object that will be pointed to by a reference. No other fields may be specified when creating a reference.	Optional*
value	JSON String	JSON-encoded data. • If this field is not included, an empty JSON String ("") will be assigned as the field value. • Binary data must be escaped as per the JSON escaping rules described in RFC4627.	Optional*

*Only one of these parameters shall be specified in any given operation, and except for value, these fields are not persisted.

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the object as specified in the request.	Mandatory
objectID	JSON String	Object ID of the object	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain.	Mandatory
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
completionStatus	JSON String	A string indicating if the object is still in the process of being created, and once the operation is complete, if it was created successfully or an error occurred. The value shall be the string "Processing", the string "Complete", or an error message.	Mandatory
percentComplete	JSON String	The value shall be an integer numeric value from 0 through 100	Optional

Name	Type	Description	Mandatory/Optional
Mimetype	JSON String	Mime type of the value of the data object	Mandatory
Metadata	JSON Object	Metadata for the data object. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory

Response Status:

HTTP Status	Description
201 Created	New data object was created
202 Accepted	Data object is in the process of being created. Investigate completionStatus and percentComplete parameters to determine the current status of the operation.
304 Not Modified	The operation conflicts because the object already exists and the X-CDMI-NoClobber header element was set to "true".
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

PUT to the container URI the data object name and contents

```
PUT /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "mimetype" : "text/plain",
    "metadata" : {

    },
    "value" : "This is the Value of this Data Object"
}
```

The response looks like:

```
HTTP/1.1 201 Created
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/MyDataObject.txt",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/DataObject",
    "completionStatus" : "Complete",
    "mimetype" : "text/plain",
    "metadata" : {

    }
}
```

Example Request:

PUT to the container URI a move from an existing data object

```
PUT /MyContainer/MySecondDataObject.txt HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "copy" : "/MyContainer/MyDataObject.txt"
}
```

The response looks like:

```
HTTP/1.1 201 Created
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/MySecondDataObject.txt",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/DataObject",
    "completionStatus" : "Complete",
    "mimetype" : "text/plain",
    "metadata" : {

    }
}
```

8.3 Create a Data Object (Non-CDMI Content Type)

Synopsis:

Creates a new data object at the specified URI.

```
PUT <root URI>/<ContainerName>/<DataObjectName>
```

- <root URI> is the path to the CDMI cloud.

- <ContainerName> is zero or more intermediate containers that already exist.
- <DataObjectName> is the name specified for the data object to be created.

Once created, the object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when creating a new data object:

- Support for the ability to create a new data object is indicated by the presence of the "cdmi_create_dataobject" capability in the parent container.

Request Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	The content-type of the data to be stored as a data object. The value specified here shall be used in the "mimetype" field of the CDMI data object.	Mandatory
X-CDMI-Partial	Header String	"true". Indicates that the newly created object is part of a series of writes and has not yet been fully created. When set, the "completionStatus" field will be set to "Processing".	Optional

Request Message Body:

The data to be stored in the value of the data object.

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
201 Created	New data object was created
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

PUT to the container URI the data object name and contents

```
PUT /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Content-Type: text/plain
Content-Length: 37
This is the Value of this Data Object
```

The response looks like:

```
HTTP/1.1 201 Created
```

8.4 Read a Data Object (CDMI Content Type)

Synopsis:

Reads from an existing data object at the specified URI.

```
GET <root URI>/<ContainerName>/<DataObjectName>
GET <root URI>/<ContainerName>/<DataObjectName>?<fieldname>;<fieldname>;...
GET <root URI>/<ContainerName>/<DataObjectName>?value:<range>;...
GET <root URI>/<ContainerName>/<DataObjectName>?metadata:<prefix>;...
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <DataObjectName> is the name of the data object to be read from.
- <fieldname> is the name of a field from the response message body.
- <range> is a byte range within the data object value field.
- <prefix> is a matching prefix that returns all metadata items that start with the prefix value.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when reading an existing data object:

- Support for the ability to read the metadata of an existing data object is indicated by the presence of the "cdmi_read_metadata" capability in the specified object.
- Support for the ability to read the value of an existing data object is indicated by the presence of the "cdmi_read_value" capability in the specified object. Any read from a specific byte location not previously written to by a create or update operation shall return zero for the byte value.
- Support for the ability to read the value of an existing data object in specific byte ranges is indicated by the presence of the "cdmi_read_value_range" capability in the specified object. Any read from a specific byte location within the value range specified not previously written to by a create or update operation shall return zero for the byte value.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.object+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the object as specified in the request.	Mandatory
objectID	JSON String	Object ID of the object	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain	Mandatory
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
completionStatus	JSON String	A string indicating if the object is still in the process of being created, and once the operation is complete, if it was created successfully or an error occurred. The value shall be the string "Processing", the string "Complete", or an error message.	Mandatory

Name	Type	Description	Mandatory/Optional
percentComplete	JSON String	The value shall be an integer numeric value from 0 through 100.	Optional
mimetype	JSON String	Mime type of the value of the data object	Mandatory
metadata	JSON Object	Metadata for the data object. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory
valuerange	JSON String	The range of bytes of the value returned in the value field.	Mandatory
value	String	The data object value encoded in JSON. The value field is only provided when completionStatus is "Complete".	Mandatory

If individual fields are specified in the GET request, only these fields are returned in the result body. Optional fields that are requested but do not exist are omitted from the result body. Requesting fields not defined in the standard result in a 400 Bad Request HTTP status code.

Response Status:

HTTP Status	Description
200 OK	Valid response is enclosed
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	A data object was not found at the specified URI.
406 Not Acceptable	The server is unable to provide the object in the content-type specified in the Accept header.

Example Request:

GET to the data object URI to read all fields of the data object

```
GET /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/MyDataObject.txt",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain",
    "capabilitiesURI" : "/cdmi_capabilities/DataObject",
    "completionStatus" : "Complete",
    "mimetype" : "text/plain",
    "metadata" : {

    },
    "valuerange" : "0-37",
    "value" : "This is the Value of this Data Object"
}
```

Example Request:

GET to the data object URI to read the value and mimetype of the data object

```
GET /MyContainer/MyDataObject.txt?value;mimetype HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "value" : "This is the Value of this Data Object",
    "mimetype" : "text/plain"
}
```

Example Request:

GET to the data object URI to read the first ten bytes of the value of the data object

```
GET /MyContainer/MyDataObject.txt?valuerange;value:0-10 HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "valuerange" : "0-10",
    "value" : "This is th"
}
```

8.5 Read a Data Object (Non-CDMI Content Type)

Synopsis:

Reads from an existing data object at the specified URI.

```
GET <root URI>/<ContainerName>/<DataObjectName>
GET <root URI>/<ContainerName>/<DataObjectName>?<fieldname>
GET <root URI>/<ContainerName>/<DataObjectName>?metadata:<prefix>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <DataObjectName> is the name of the data object to be read from.
- <fieldname> is the name of a field from the response message body.
- <prefix> is a matching prefix that returns all metadata items that start with the prefix value.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when reading an existing data object:

- Support for the ability to read the metadata of an existing data object is indicated by the presence of the "cdmi_read_metadata" capability in the specified object.
- Support for the ability to read the value of an existing data object is indicated by the presence of the "cdmi_read_value" capability in the specified object. Any read from a specific byte location not previously written to by a create or update operation shall return zero for the byte value.
- Support for the ability to read the value of an existing data object in specific byte ranges is indicated by the presence of the "cdmi_read_value_range" capability in the specified object. Any read from a specific byte location within the value range specified not previously written to by a create or update operation shall return zero for the byte value.

Request Headers:

N/A

Request Message Body:

N/A

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	If a field was not specified, or the value field was specified, the content-type returned shall be the "mimetype" field in the data object. If a non-value field was specified, the content-type shall be "text/json"	Mandatory
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

- If no fields were specified in the request or the value field was specified in the request, the response message body shall be the contents of the data object's value field.
- If a field other than the value field was specified in the request, the value of that specified field shall be returned in JSON format.
- Requesting an optional field that is not present results in an HTTP status code of 404 Not Found.
- Requesting an undefined field results in an HTTP status codeof 400 Bad Request .

Response Status:

HTTP Status	Description
200 OK	Data object contents in response
204 No Content	Data object may not be complete, retry later
206 Partial Content	A requested range of the data object content was returned in response
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	A data object was not found at the specified URI, or a requested field within the data object was not found.

Example Request:

GET to the data object URI to read the value of the data object

```
GET /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: text/plain
Content-Length: 37
This is the Value of this Data Object
```

Example Request:

GET to the data object URI to read the mimetype field of the data object

```
GET /MyContainer/MyDataObject.txt?mimetype HTTP/1.1
Host: cloud.example.com
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: text/json
{
    "mimetype" : "text/plain"
}
```

Example Request:

GET to the data object URI to read the first ten bytes of the value of the data object

```
GET /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Range: bytes=0-10
```

The response looks like:

```
HTTP/1.1 206 Partial Content
Content-Type: text/plain
Content-Range: bytes 0-10
Content-Length: 11
This is the
```

8.6 Update a Data Object (CDMI Content Type)

Synopsis:

Updates an existing data object at the specified URI.

```
PUT <root URI>/<ContainerName>/<DataObjectName>
PUT <root URI>/<ContainerName>/<DataObjectName>?metadata
PUT <root URI>/<ContainerName>/<DataObjectName>?value
PUT <root URI>/<ContainerName>/<DataObjectName>?value:<range>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <DataObjectName> is the name of the data object to be updated.
- <range> is a byte range within the data object value field.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>, and an update shall not result in a change to the Object ID.

Capabilities:

The following capabilities describe the supported operations that can be performed when updating an existing data object:

- Support for the ability to modify the metadata of an existing data object is indicated by the presence of the "cdmi_modify_metadata" capability in the specified object.
- Support for the ability to modify the value of an existing data object is indicated by the presence of the "cdmi_modify_value" capability in the specified object.
- Support for the ability to modify the value of an existing data object in specified byte ranges is indicated by the presence of the "cdmi_modify_value_range" capability in the specified object.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory
X-CDMI-MustExist	Header String	"true". Fail updates if the object does not exist. If this header element exists and is set to "true", it is an error for the object to not already exist.	Optional
X-CDMI-Partial	Header String	"true". Indicates that the object is in the process of being updated, and has not yet been fully updated. When set, the "completionStatus" field will be set to "Processing". If the "completionStatus" field had previously been set to "Processing" by including this header in a create or update, the next update without this field will change the "completionStatus" field back to "Complete".	Optional

Request Message Body:

Name	Type	Description	Mandatory/Optional
mimetype	JSON String	Mime type of the data contained within the value field of the data object. If present, this replaces the existing mimetype.	Optional
metadata	JSON Object	Metadata for the data object. If present, this replaces the existing metadata. See Chapter 16, “Metadata” for a further description of metadata.	Optional
domainURI	JSON String	URI of the owning domain. • If different from the parent domain, the user must have the "cross_domain" privilege. • If not specified, the parent domain will be used.	Optional

Name	Type	Description	Mandatory/Optional
value	JSON String	This is the new data for the object. If present, this replaces the existing value. • If a value range was specified in the request, the new data is inserted at the location specified by the range. Any resulting gaps between ranges should be treated as all zeros, and included when calculating the size of the value. • Binary data must be escaped as per the JSON escaping rules described in RFC4627.	Optional

Response Headers:

Header	Type	Value	Mandatory/Optional
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	New metadata and/or content accepted
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	An update was attempted on an object that does not exist, and the X-CDMI-MustExist header element was set to "true".
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

PUT to the data object URI to set new field values

```
PUT /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "mimetype" : "text/plain",
    "metadata" : {

    },
    "value" : "This is the Value of this Data Object"
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

Example Request:

PUT to the data object URI to set a new mimetype

```
PUT /MyContainer/MyDataObject.txt?mimetype HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "mimetype" : "text/plain"
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

Example Request:

`PUT to the data object URI to update a range of the value`

```
PUT /MyContainer/MyDataObject.txt?value:21-24 HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "value" : "that"
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

8.7 Update a Data Object (Non-CDMI Content Type)

Synopsis:

Updates an existing data object at the specified URI.

```
PUT <root URI>/<ContainerName>/<DataObjectName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <DataObjectName> is the name of the data object to be updated.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>, and an update shall not result in a change to the Object ID.

Capabilities:

The following capabilities describe the supported operations that can be performed when updating an existing data object:

- Support for the ability to modify the value of an existing data object is indicated by the presence of the "cdmi_modify_value" capability in the specified object.
- Support for the ability to modify the value of an existing data object in specified byte ranges is indicated by the presence of the "cdmi_modify_value_range" capability in the specified object.

Request Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	The content-type of the data to be stored as a data object. The value specified here shall be used in the "mimetype" field of the CDMI data object.	Mandatory
X-CDMI-Partial	Header String	"true". Indicates that the object is in the process of being updated and has not yet been fully updated. When set, the "completionStatus" field will be set to "Processing". If the "completionStatus" field had previously been set to "Processing" by including this header in a create or update, the next update without this field will change the "completionStatus" field back to "Complete".	Optional

Request Message Body:

The data to be stored in the value of the data object.

Response Headers:

Header	Type	Value	Mandatory/Optional
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	New value accepted
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

PUT to the data object URI to read the value of the data object

```
PUT /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Content-Type: text/plain
Content-Length: 37
This is the value of this data object
```

The response looks like:

```
HTTP/1.1 200 OK
```

Example Request:

PUT to the data object URI to set a new mimetype

```
PUT /MyContainer/MyDataObject.txt?mimetype HTTP/1.1
Host: cloud.example.com
Content-Type: text/plain
Content-Length: 41
This is the new value of this data object
```

The response looks like:

```
HTTP/1.1 200 OK
```

Example Request:

PUT to the data object URI to read the first ten bytes of the value of the data object

```
PUT /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Content-Range: bytes=21-24
Content-Type: text/plain
Content-Length: 4
that
```

The response looks like:

```
HTTP/1.1 200 OK
```

8.8 Delete a Data Object (CDMI Content Type)

Synopsis:

Deletes an existing data object at the specified URI.

```
DELETE <root URI>/<ContainerName>/<DataObjectName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <DataObjectName> is the name of the data object to be deleted.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when deleting an existing data object:

- Support for the ability to delete an existing data object is indicated by the presence of the "cdmi_delete_object" capability in the specified object.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Data object was successfully deleted
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The resource specified was not found
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server or he data object cannot be deleted.

Example Request:

DELETE to the data object URI

```
DELETE /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
```

8.9 Delete a Data Object (Non-CDMI Content Type)

Synopsis:

Deletes an existing data object at the specified URI.

```
DELETE <root URI>/<ContainerName>/<DataObjectName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <DataObjectName> is the name of the data object to be read from.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when deleting an existing data object:

- Support for the ability to delete an existing data object is indicated by the presence of the "cdmi_delete_object" capability in the specified object.

Request Headers:

N/A

Request Message Body:

N/A

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Data object was successfully deleted
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The resource specified was not found
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server or he data object cannot be deleted.

Example Request:

DELETE to the container URI

```
DELETE /MyContainer/MyDataObject.txt HTTP/1.1
Host: cloud.example.com
```

The response looks like:

```
HTTP/1.1 200 OK
```

9 Container Objects

9.1 Overview

Container objects are the fundamental grouping of stored data within CDMI and are analogous to directories within a filesystem. Each container has zero or more child objects and a set of well-defined fields that include standardized and optional metadata generated by the cloud storage system and specified by the cloud user.

Containers are addressed in CDMI in the two following ways:

- `http://cloud.example.com/container/`
- `http://cloud.example.com/cdmi_objectid/AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==`

The first example addresses the container by URI, and the second addresses the container by CDMI object ID. Every container has a single, globally-unique object identifier that remains constant for the life of the object. Each container may also have one or more URI addresses that allow the container to be accessed.

Containers can also be nested, as follows:

```
http://cloud.example.com/container/sub-container/
```

A container may have a parent object. In this case, the container inherits data system metadata from its parent object. For example, the "sub-container" container can inherit its data system metadata from the parent container "container".

This model allows direct mapping between CDMI-managed cloud storage and filesystems (for example), as CDMI containers can be exported as NFSv4 or WebDAV filesystems, with all metadata visible. As files are created, the files and directories are then visible through the CDMI interface acting as a data path. This mapping, though possible, is not further described in this specification.

Individual fields within a container can be accessed by specifying the field name after a question mark "?" appended to the end of the container URI. For example, the below URI would return just the children field in the response body:

```
http://cloud.example.com/container?children
```

By specifying a range after the children field name, specific ranges of the children field can be accessed. For example, the below URI returns the first two children from the children field:

```
http://cloud.example.com/container?children:0-2
```

Children ranges are specified in a similar fashion to byte ranges as per Section 14.35.1 of RFC2616.

A list of fields, separated by a semicolon ";" can be specified, allowing multiple fields to be accessed in a single request. For example, the below URI would return the children and metadata fields in the response body:

```
http://cloud.example.com/container?children;metadata
```

9.1.1 Container Metadata

The following optional data system metadata may be provided:

Metadata Name	Description	Source	Permissions
cdmi_assignedsize	The number of bytes that is reported via exported protocols (may be thin provisioned). This number may limit cdmi_size.	Client	Read-Write

Container metadata can also include arbitrary user-supplied metadata and data system metadata as described in Chapter 16, “Metadata”.

9.1.2 Container Object Addressing

Each container object is addressed via one or more unique URIs, and all operations may be performed through any of these URIs. For example, a data object could be accessible via multiple virtual hosting paths, where "http://cloud.example.com/users/snia/cdmi/" is also accessible through "http://snia.example.com/cdmi/". Conflicting writes via different paths are managed the same way that conflicting writes via one path are managed, via the principle of eventual consistency (see Section 9.2, “Create a Container (CDMI Content Type)”).

9.1.3 Container Object Representations

The representations in this section are shown using JSON notation. A conforming implementation shall support the mandatory parameters and may support the optional parameters. The parameter fields may be specified or returned in any order. Both clients and servers shall support JSON representation.

9.2 Create a Container (CDMI Content Type)

Synopsis:

Creates a new container at the specified URI.

```
PUT <root URI>/<ContainerName>/<NewContainerName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers that already exist.
- <NewContainerName> is the name specified for the container to be created.
- Once created, the container can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Delayed Completion of Create:

On a create operation for a container, the server may return a response of "202 Accepted". In this case, the container is in the process of being created. This response is particularly useful for long-running operations, for instance, for deserializing a source data object to create a large container hierarchy. Such a response has the following implications:

- The server returns an object identifier along with the "202 Accepted." With "202 Accepted", the server implies that the following checks have passed:
  - — User authorization for creating the container
  - — User authorization for read access to any source object for move, copy, serialize, or deserialize
  - — Availability of space to create the container or at least enough space to create a URI to report an error
- Future accesses to the URI created (or the object ID) will succeed modulo any delays due to use of eventual consistency.
- The client performs GET operations to the URI to track the progress of the operation. In particular, the server returns two fields in its response body to indicate progress:
  - — A mandatory completionStatus text field contains either "Processing", "Complete", or an error message
  - — An optional percentComplete field that indicates the percentage to which the last PUT has completed (0 to 100). GET does not return any value for the object when completionStatus is not "Complete".
- When the final result of the create operation is an error, the URI is created with the completionStatus field set to the error message. It is the client's responsibility to delete the URI after the error has been noted.

Capabilities:

The following capabilities describe the supported operations that can be performed when creating a new container:

- Support for the ability to create a new container object is indicated by the presence of the "cdmi_create_container" capability in the parent container.
- If the new container object is a reference of an existing container object, support for the ability to create the reference is indicated by the presence of the "cdmi_create_reference" capability in the parent container.
- If the new container object is a copy of an existing container, support for the ability to copy is indicated by the presence of the "cdmi_create_copy" capability in the parent container.
- If the new container is the destination of a move, support for the ability to move the container is indicated by the presence of the "cdmi_create_move" capability in the parent container.
- If the new container is the destination of a deserialize operation, support for the ability to deserialize the source data object serialization of a container is indicated by the presence of the "cdmi_deserialize_container" capability in the parent container.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.container+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.container+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory
X-CDMI-NoClobber	Header String	"true". Do not overwrite an existing container. If this header element is present and set to "true", it is an error for this operation to proceed. An update should be done instead.	Optional

Request Message Body:

Name	Type	Description	Mandatory/Optional
metadata	JSON Object	Metadata for the container. If this field is included when deserializing, copying, or moving a container, the value provided shall be replace the metadata from the source URI. If this field is not specified, an empty JSON object ("{}") will be assigned as the field value.	Optional
domainURI	JSON String	URI of the owning domain. If different from the parent domain, the user must have the "cross_domain" privilege. If not specified, the parent domain will be used.	Optional
exports	JSON Object	A structure for each protocol enabled for this container.	Optional
deserialize	JSON String	URI of a serialized CDMI data object that will be deserialized to create the new container, including all child objects inside the source serialized data object. When deserializing a container, any exported protocols from the original serialized container are not applied to the newly created container(s).	Optional*
copy	JSON String	URI of a CDMI container that will be copied into the new container, including all child objects under the source container. When copying a container, exported protocols are not preserved across the copy.	Optional*
move	JSON String	URI of a CDMI container that will be copied into the new container, including all child objects under the source container., then removing the container at the source URI upon the successful completion of the copy.	Optional*
reference	JSON String	URI of a CDMI data object that will be pointed to by a reference. No other fields may be specified when creating a reference.	Optional*

*If present, only one of these parameters shall be specified in any given operation, and these fields are not persisted.

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.container+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the container as specified in the request.	Mandatory
objectID	JSON String	Object ID of the object	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain	Mandatory
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
completionStatus	JSON String	A string indicating if the object is still in the process of being created, and once the operation is complete, if it was created successfully or an error occurred. The value shall be the string "Processing", the string "Complete", or an error message.	Mandatory
percentComplete	JSON String	The value shall be an integer numeric value from 0 through 100	Optional
metadata	JSON Object	Metadata for the container. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory
exports	JSON Object	A structure for each protocol that is enabled for this container. See Chapter 13, “Exported Protocols”.	Optional (returned only if present)
snapshots	JSON Array	URI(s) of the SnapShot containers. See Chapter 14, “Snapshots”.	Optional (returned only if present)

Name	Type	Description	Mandatory/Optional
childrenrange	JSON String	The range of the children returned in the children field.	Mandatory
children	JSON Array	Names of the children objects in the container. Child containers end with "/".	Mandatory

Response Status:

HTTP Status	Description
201 Created	New container was created
202 Accepted	Container is in the process of being created. Investigate completionStatus and percentComplete parameters to determine the current status of the operation.
304 Not Modified	The operation conflicts because the container already exists and the X-CDMI-NoClobber header element was set to "true".
400 Bad Request	Invalid parameter of field names in the request.
401 Unauthenticated	Incorrect or missing authentication credentials.
403 Unauthorized	Client lacks the proper authorization to perform this request.
409 Conflict	The container name already exists.

Example Request:

PUT to the URI the container name and metadata

```
PUT /MyContainer HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.container+json
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "metadata" : {

    },
    "exports" : {
        "OCCI/iSCSI" : {
            "identifier" :
   "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
            "permissions" : "f63aaa26-30b7-4a30-91ca-1d03c1e52214"
        },
        "Network/NFSv4" : {
            "identifier" : "/users",
            "permissions" : "domain"
        }
    }
}
```

The response looks like:

```
HTTP/1.1 201 Created
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/Container",
    "completionStatus" : "Complete",
    "metadata" : {

    },
    "exports" : {
        "OCCI/iSCSI" : {
            "identifier" :
   "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
            "permissions" : "f63aaa26-30b7-4a30-91ca-1d03c1e52214"
        },
        "Network/NFSv4" : {
            "identifier" : "/users",
            "permissions" : "domain"
        }
    },
    "childrenrange" : "0-0",
    "children" : [

    ]
}
```

9.3 Create a Container (Non-CDMI Content Type)

Synopsis:

Creates a new container at the specified URI.

```
PUT <root URI>/<ContainerName>/<NewContainerName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers that already exist.
- <NewContainerName> is the name specified for the container to be created.

Once created, the container can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when creating a new container:

- Support for the ability to create a new container object is indicated by the presence of the "cdmi_create_container" capability in the parent container.

Request Headers:

N/A

Request Message Body:

N/A

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
201 Created	New container was created
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
409 Conflict	The container name already exists

Example Request:

PUT to the URI the container name

```
PUT /MyContainer HTTP/1.1
Host: cloud.example.com
```

The response looks like:

```
HTTP/1.1 201 Created
```

9.4 Read a Container Object (CDMI Content Type)

Synopsis:

Reads from an existing container at the specified URI.

```
GET <root URI>/<ContainerName>/<TheContainerName>
GET <root URI>/<ContainerName>/<TheContainerName>?<fieldname>;<fieldname>;...
GET <root URI>/<ContainerName>/<TheContainerName>?children:<range>;...
GET <root URI>/<ContainerName>/<TheContainerName>?metadata:<prefix>;...
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <TheContainerName> is the name specified for the container to be read from.
- <fieldname> is the name of a field from the response message body.
- <range> is a numeric range within the list of children.
- <prefix> is a matching prefix that returns all metadata items that start with the prefix value.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when reading an existing container:

- Support for the ability to read the metadata of an existing container object is indicated by the presence of the "cdmi_read_metadata" capability in the specified container.
- Support for the ability to list the children of an existing container is indicated by the presence of the "cdmi_list_children" capability in the specified container.
- Support for the ability to list ranges of the children of an existing container is indicated by the presence of the "cdmi_list_children_range" capability in the specified container.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.container+json"	Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.object+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.container+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the object as specified in the request.	Mandatory
objectID	JSON String	Object ID of the object	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain	Mandatory
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
completionStatus	JSON String	A string indicating if the object is still in the process of being created, and once the operation is complete, if it was created successfully or an error occurred. The value shall be the string "Processing", the string "Complete", or an error message.	Mandatory
percentComplete	JSON String	The value shall be an integer numeric value from 0 through 100.	Optional
metadata	JSON Object	Metadata for the container. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory
exports	JSON Object	A structure for each protocol that is enabled for this container.	Optional (returned only if present)
snapshots	JSON Array	URI(s) of the SnapShot containers.	Optional (returned only if present)

Name	Type	Description	Mandatory/Optional
childrenrange	JSON String	The range of the children returned in the children field.	Mandatory
children	JSON Array	Names of the children objects in the container. Child containers end with "/".	Mandatory

If individual fields are specified in the GET request, only these fields are returned in the result body. Optional fields that are requested but do not exist are omitted from the result body. Requesting fields not defined in the standard result in a 400 Bad Request HTTP status code.

Response Status:

HTTP Status	Description
200 OK	Metadata for the container Object provided in the Message Body
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	A container was not found at the specified URI.
406 Not Acceptable	The server is unable to provide the object in the content-type specified in the Accept header.

Example Request:

GET to the container URI to read all the fields of the container

```
GET /MyContainer HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.container+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/",
    "domainURI" : "/cdmi_domains/MyDomain",
    "capabilitiesURI" : "/cdmi_capabilities/Container",
    "completionStatus" : "Complete",
    "metadata" : {

    },
    "exports" : {
        "OCCI/iSCSI" : {
            "identifier" :
   "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
            "permissions" : "f63aaa26-30b7-4a30-91ca-1d03c1e52214"
        },
        "Network/NFSv4" : {
            "identifier" : "/users",
            "permissions" : "domain"
        },
        "childrenrange" : "0-4",
        "children" : [
            "red",
            "green",
            "yellow",
            "orange/",
            "purple/"
        ]
    }
}
```

Example Request:

GET to the container URI to read parentURI and children of the container

```
GET /MyContainer?parentURI;children HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.container+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "parentURI" : "/",
    "children" : [
        "red",
        "green",
        "yellow",
        "orange/",
        "purple/"
    ]
}
```

Example Request:

GET to the container URI to read children 0..2 of the container

```
GET /MyContainer?childrenrange;children:0-2 HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.container+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "childrenrange" : "0-2",
    "children" : [
        "red",
        "green",
        "yellow"
    ]
}
```

9.5 Read a Container Object (Non-CDMI Content Type)

Synopsis:

Reads from an existing container at the specified URI.

```
GET <root URI>/<ContainerName>/<TheContainerName>?<fieldname>
GET <root URI>/<ContainerName>/<TheContainerName>?children:<range>
GET <root URI>/<ContainerName>/<TheContainerName>?metadata:<prefix>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <TheContainerName> is the name specified for the container to be read from.
- <fieldname> is the name of a field from the response message body.
- <range> is a numeric range within the list of children.
- <prefix> is a matching prefix that returns all metadata items that start with the prefix value.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when reading an existing container:

- Support for the ability to read the metadata of an existing container object is indicated by the presence of the "cdmi_read_metadata" capability in the specified container.
- Support for the ability to list the children of an existing container is indicated by the presence of the "cdmi_list_children" capability in the specified container.
- Support for the ability to list ranges of the children of an existing container is indicated by the presence of the "cdmi_list_children_range" capability in the specified container.

Request Headers:

N/A

Request Message Body:

N/A

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"text/json"	Mandatory
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

- The value of the specified field shall be returned in JSON format.
- Requesting an optional field that is not present results in a 404 Not Found HTTP status code.
- Requesting an undefined field results in a 400 Bad Request HTTP status code.

Response Status:

HTTP Status	Description
200 OK	Metadata for the container Object provided in the Message Body
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	A container was not found at the specified URI.

Example Request:

GET to the container URI to read parentURI of the container

```
GET /MyContainer?parentURI HTTP/1.1
Host: cloud.example.com
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: text/json
{
    "parentURI" : "/"
}
```

Example Request:

GET to the container URI to read children 0..2 of the container

```
GET /MyContainer?childrenrange;children:0-2 HTTP/1.1
Host: cloud.example.com
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: text/json
{
    "children" : [
        "red",
        "green",
        "yellow"
    ]
}
```

9.6 Update a Container (CDMI Content Type)

Synopsis:

Updates an existing container at the specified URI.

```
PUT <root URI>/<ContainerName>/<TheContainerName>
PUT <root URI>/<ContainerName>/<TheContainerName>?metadata
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <TheContainerName> is the name of the container to be updated.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>, and an update shall not result in a change to the Object ID.

Delayed completion of snapshot: On a snapshot operation for a container, the server may return a response of "202 Accepted". Such a response has the following implications:

- With "202 Accepted", the server implies that the following checks have passed:
  - — User authorization for creating the snapshot
  - — User authorization for read access to the container
- Availability of space to create the snapshot or at least enough space to create a URI to report an error.
- Future accesses to the snapshot URI will succeed modulo any delays due to use of eventual consistency.

The client performs GET operations to the snapshot URI to track the progress of the operation. In particular, the server returns two fields in its response body to indicate progress:

- A completionStatus text field contains either "Processing", "Complete", or an error message

- An optional percentComplete field that indicates the percentage to which the last PUT has completed (0 to 100). GET does not return any value for the object when completionStatus is not "Complete".

When the final result of the snapshot operation is an error, the snapshot URI is created with the completionStatus field set to the error message. It is the client's responsibility to delete the URI after the error has been noted.

Capabilities:

The following capabilities describe the supported operations that can be performed when updating an existing container:

- Support for the ability to modify the metadata of an existing container is indicated by the presence of the "cdmi_modify_metadata" capability in the specified container.
- Support for the ability to snapshot the contents of an existing container is indicated by the presence of the "cdmi_snapshot" capability in the specified container.
- Support for the ability to add an exported protocol to an existing container is indicated by the presence of the "cdmi_export_<protocol>" capabilities for the specified container.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.container+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.container+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory
X-CDMI-MustExist	Header String	"true". Fail updates if the object does not exist. If this header element exists and is set to "true", it is an error for the object to not already exist.	Optional

Request Message Body:

Name	Type	Description	Mandatory/Optional
metadata	JSON Object	Metadata for the container. If present, this replaces the existing metadata. See Chapter 16, “Metadata” for a further description of metadata.	Optional
domainURI	JSON String	URI of the owning domain. If different from the parent domain, the user must have the "cross_domain" privilege. If not specified, the parent domain will be used.	Optional

Name	Type	Description	Mandatory/Optional
snapshot	JSON String	Name of the snapshot to be taken. If a snapshot is added or altered, the PUT operation only returns after the snapshot is added to the snapshot list. Once created, snapshots can be accessed as children containers under the cdmi_snapshots child container of the container receiving a snapshot.	Optional
exports	JSON Object	A structure for each protocol that is enabled for this container. If an exported protocol is added or altered, the PUT operation only returns after the export operation has completed.	Optional

Response Headers:

Header	Type	Value	Mandatory/Optional
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Container was updated.
202 Accepted	Container or a snapshot (sub-container) is in the process of being created. Investigate completionStatus and percentComplete parameters to determine the current status of the operation.
302 Found	The URI is a reference to another URI.
400 Bad Request	Invalid parameter of field names in the request.
401 Unauthenticated	Incorrect or missing authentication credentials.
403 Unauthorized	Client lacks the proper authorization to perform this request.
404 Not Found	An update was attempted on a container that does not exist, and the X-CDMI-MustExist header element was set to "true".
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

PUT to the container URI to set new field values

```
PUT /MyContainer HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.container+json
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "metadata" : {

    } ,
    "exports" : {
        "OCCI/iSCSI" : {
            "identifier" :
   "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
            "permissions" : "f63aaa26-30b7-4a30-91ca-1d03c1e52214"
        },
        "Network/NFSv4" : {
            "identifier" : "/users",
            "permissions" : "domain"
        }
    }
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

Example Request:

PUT to the container URI to set a new exported protocol value

```
PUT /MyContainer?exports HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.container+json
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
{
    "exports" : {
        "OCCI/iSCSI" : {
            "identifier" :
   "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
            "permissions" : "f63aaa26-30b7-4a30-91ca-1d03c1e52214"
        } ,
        "Network/NFSv4" : {
            "identifier" : "/users",
            "permissions" : "domain"
        }
    }
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

9.7 Delete a Container Object (CDMI Content Type)

Synopsis:

Deletes an existing container, all contained children, and snapshots at the specified URI.

```
DELETE <root URI>/<ContainerName>/<TheContainerName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <TheContainerName> is the name of the container to be deleted.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when deleting an existing container:

- Support for the ability to delete an existing data object is indicated by the presence of the "cdmi_delete_container" capability in the specified container.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.container+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.container+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Container object was successfully deleted
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The resource specified was not found
409 Conflict	The container object cannot be deleted

Example Request:

DELETE to the container URI

```
DELETE /MyContainer HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.container+json
Content-Type: application/vnd.org.snia.cdmi.container+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
```

9.8 Delete a Container Object (Non-CDMI Content Type)

Synopsis:

Deletes an existing container, all contained children and snapshots at the specified URI.

```
DELETE <root URI>/<ContainerName>/<TheContainerName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <TheContainerName> is the name of the container to be deleted.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when deleting an existing container:

- Support for the ability to delete an existing data object is indicated by the presence of the "cdmi_delete_object" capability in the specified container.

Request Headers:

N/A

Request Message Body:

N/A

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Container object was successfully deleted
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The resource specified was not found
409 Conflict	The container object cannot be deleted

Example Request:

DELETE to the container URI

```
DELETE /MyContainer HTTP/1.1
Host: cloud.example.com
```

The response looks like:

```
HTTP/1.1 200 OK
```

9.9 Create a New Data Object (CDMI Content Type)

Synopsis:

Creates a new data object as a child of the specified container URI.

```
POST <root URI>/<ContainerName>/
POST <root URI>/cdmi_objectid/
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers that already exist.

Once created, the object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Delayed Completion of Create. On a create operation for a data object, the server may return a response of `202 Accepted`. In this case, the object is in the process of being created. This response is particularly useful for long-running operations, for instance, copying a large data object from a source URI. Such a response has the following implications:

- The server returns an object identifier along with the `202 Accepted`.
- With `202 Accepted`, the server implies that the following checks have passed:
  - — User authorization for creating the object
  - — User authorization for read access to any source object for move, copy, serialize, or deserialize
  - — Availability of space to create the object or at least enough space to create a URI to report an error
- Future accesses to the URI created (or the object ID) will succeed modulo any delays due to use of eventual consistency.

The client performs GET operations to the URI to track the progress of the operation. In particular, the server returns two fields in its response body to indicate progress:

- A mandatory completionStatus text field contains either `Processing`, `Complete`, or an error message
- An optional percentComplete field that indicates the percentage to which the last PUT has completed (0 to 100).

GET does not return any value for the object when completionStatus is not `Complete`. When the final result of the create operation is an error, the URI is created with the completionStatus field set to the error message. It is the client's responsibility to delete the URI after the error has been noted.

Capabilities:

The following capabilities describe the supported operations that can be performed when creating a new data object:

- Support for the ability to create data objects through this operation is indicated by both the presence of the "cdmi_post_dataobject" capability the presence of the "cdmi_create_dataobject" capability in the specified container.
- If the new data object is a reference of an existing data object, support for the ability to create the reference is indicated by the presence of the "cdmi_create_reference" capability in the parent container.
- If the new data object is a copy of an existing data object, support for the ability to copy is indicated by the presence of the "cdmi_create_copy" capability in the parent container.
- If the new data object is the destination of a move, support for the ability to move the data object is indicated by the presence of the "cdmi_create_move" capability in the parent container.
- If the new data object is the destination of a deserialize operation, support for the ability to deserialize the source data object is indicated by the presence of the "cdmi_deserialize_dataobject" capability in the parent container.
- If the new data object is the destination of a serialize operation, support for the ability to serialize the source data object is indicated by the presence of the "cdmi_serialize_dataobject", "cdmi_serialize_container", "cdmi_serialize_domain", or "cdmi_serialize_queue" capability in the parent container.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

Name	Type	Description	Mandatory/Optional
mimetype	JSON String	Mime type of the data contained within the value field of the data object. This field shall not be included when deserializing, serializing, copying, moving, or referencing a data object. If this field is not specified, the value of "text/plain" will be assigned as the field value.	Optional
metadata	JSON Object	Metadata for the data object. • If this field is included when deserializing, serializing, copying, or moving a data object, the value provided shall replace the metadata from the source URI. • This field shall not be included when referencing a data object. • If this field is not specified, an empty JSON object ("{}") will be assigned as the field value.	Optional
domainURI	JSON String	URI of the owning domain. • If different from the parent domain, the user must have the "cross_domain" privilege. • If not specified, the parent domain will be used.	Optional
deserialize	JSON String	URI of a serialized CDMI data object that will be deserialized to create the new data object.	Optional*
serialize	JSON String	URI of a CDMI object that will be serialized into the new data object.	Optional*
copy	JSON String	URI of a CDMI data object or queue that will be copied into the new data object.	Optional*
move	JSON String	URI of a CDMI data object or queue that will be copied into the new data object, then removing the data object or queue value at the source URI upon the successful completion of the copy.	Optional*

Name	Type	Description	Mandatory/Optional
reference	JSON String	URI of a CDMI data object that will be pointed to by a reference. No other fields may be specified when creating a reference.	Optional*
value	JSON String	JSON-encoded data. If this field is not included, an empty JSON String ("") will be assigned as the field value. Binary data must be escaped as per the JSON escaping rules described in RFC4627.	Optional*

*Only one of these parameters shall be specified in any given operation, and except for value, these fields are not persisted.

Response Headers:

Header	Type	Value	Mandatory/Optional
	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory
Location	Header String	The unique URI for the new data object as assigned by the system. In the absence of file name information from the client the system shall assign the URI in the form: <root URI>/<ContainerName>/<ObjectID>.	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the object as assigned by the system.	Mandatory
objectID	JSON String	Object ID of the object	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain	Mandatory
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
completionStatus	JSON String	A string indicating if the object is still in the process of being created, and once the operation is complete, if it was created successfully or an error occurred. The value shall be the string "Processing", the string "Complete", or an error message.	Mandatory

Name	Type	Description	Mandatory/Optional
percentComplete	JSON String	The value shall be an integer numeric value from 0 through 100	Optional
Mimetype	JSON String	Mime Type of the value of the data object	Mandatory
Metadata	JSON Object	Metadata for the data object. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory

Response Status:

HTTP Status	Description
201 Created	New data object was created
202 Accepted	Data object is in the process of being created. Investigate completionStatus and percentComplete parameters to determine the current status of the operation.
400 Bad Request	Invalid parameter in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The specified container URI does not exist.
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

POST to the container URI the data object contents

```
POST /MyContainer/ HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "mimetype" : "text/plain",
    "metadata" : {

    },
    "value" : "This is the Value of this Data Object"
}
```

The response looks like:

```
HTTP/1.1 201 Created
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
Location: /MyContainer/AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==
{
    "objectURI" : "/MyContainer/
   AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/DataObject",
    "completionStatus" : "Complete",
    "mimetype" : "text/plain",
    "metadata" : {

    }
}
```

Example Request:

POST to the object ID URI the data object contents

```
POST /cdmi_objectid/ HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "mimetype" : "text/plain",
    "metadata" : {

    },
    "value" : "This is the Value of this Data Object"
}
```

The response looks like:

```
HTTP/1.1 201 Created
Location: "/cdmi_objectid/AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/cdmi_objectid/
   AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/DataObject",
    "completionStatus" : "Complete",
    "mimetype" : "text/plain",
    "metadata" : {

    }
```

9.10 Create a New Data Object (Non-CDMI Content Type)

Synopsis:

Creates a new data object as a child of the specified container URI.

```
POST <root URI>/<ContainerName>/
POST <root URI>/cdmi_objectid/
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers that already exist.

Capabilities:

The following capabilities describe the supported operations that can be performed when creating a new data object:

- Support for the ability to create data objects through this operation is indicated by both the presence of the "cdmi_post_dataobject" capability the presence of the "cdmi_create_dataobject" capability in the specified container.

Request Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	Supply the mime type of the object to be created.	Mandatory

Request Message Body:

The message body shall contain the contents (value) of the data object to be created.

Response Headers:

Header	Type	Value	Mandatory/Optional
Location	Header String	The unique URI for the new data object as assigned by the system. In the absence of file name information from the client the system shall assign the URI in the form: <root URI>/<ContainerName>/<ObjectID>.	Mandatory

Response Message Body:

N/A

Response Status:

HTTP Status	Description
201 Created	New data object was created
400 Bad Request	Invalid parameter in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The specified container URI does not exist.

Example Request:

POST to the container URI the data object contents

```
POST /MyContainer/ HTTP/1.1
Host: cloud.example.com
Content-Type: text/plain
<object contents>
```

The response looks like:

```
HTTP/1.1 201 Created
Location: /MyContainer/AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==
```

Example Request:

POST to the object ID URI the data object contents

```
POST /cdmi_objectid/ HTTP/1.1
Host: cloud.example.com
Content-Type: text/plain
<object contents>
```

The response looks like:

```
HTTP/1.1 201 Created
Location: "/cdmi_objectid/AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==
```

10 Domain Objects

10.1 Overview

Domain objects represent the concept of administrative ownership of stored data within a CDMI storage system. A CDMI offering may include a hierarchy of domains that provide access to domain-related information within a CDMI context. This domain hierarchy is a series of CDMI objects that correspond to parent and child domains, with each domain corresponding to logical groupings of objects that are to be managed together. Domain measurement information about objects that are associated with each domain flow up to parent domains, facilitating billing and management operations that are typical for a cloud storage environment.

A CDMI URI may optionally include domains using the following form:

```
http://example.com/cdmi_domains/parent_domain/child_domain/
```

Domains are a special class of container that are created in the cdmi_domains container found in the root URI for the cloud storage system. If a cloud storage system supports domains, the cdmi_domains container shall be present. If the "cdmi_create_domain" capability is present for the URI of a given domain, then the cloud storage system supports the ability to create child domains under the URI.

10.1.1 Domain Metadata

The following domain-specific field shall be present for each domain:

Metadata Name	Description	Source	Permissions
cdmi_domain_enabled	Indicates if the domain is enabled and specified at the time of creation. Values can be "true" or "false". • If a domain is disabled, the cloud storage system shall not permit any operations to be performed against any URI managed by that domain. • If this metadata item is not present at the time of domain creation, the value is set to "false".	Client	Read/Write

10.1.2 Domain Summaries

Domain summaries provide summary measurement information about domain usage and billing. They are not intended to provide reporting functionality, but rather to provide a simple mechanism for gathering information about the storage operations that are associated with a domain. If supported, a domain summary container named "cdmi_domain_summary" will be present under each domain container. Like any container, the domain summary sub-container can have standard storage system metadata, such as ACLs that permit access to this information to be restricted.

Within each domain summary container are a series of domain summary data objects that are generated by the cloud storage system. The "yearly", "monthly", and "daily" containers of these data objects contain domain summary data objects corresponding to each year, month, and day, respectively. These containers are organized into the following structures:

```
http://example.com/cdmi_domains/domain/

http://example.com/cdmi_domains/domain/cdmi_domain_summary/

http://example.com/cdmi_domains/domain/cdmi_domain_summary/cumulative
```

```
http://example.com/cdmi_domains/domain/cdmi_domain_summary/daily/

http://example.com/cdmi_domains/domain/cdmi_domain_summary/daily/2009-07-01

http://example.com/cdmi_domains/domain/cdmi_domain_summary/daily/2009-07-02

http://example.com/cdmi_domains/domain/cdmi_domain_summary/daily/2009-07-03

…

http://example.com/cdmi_domains/domain/cdmi_domain_summary/monthly/

http://example.com/cdmi_domains/domain/cdmi_domain_summary/monthly/2009-07

http://example.com/cdmi_domains/domain/cdmi_domain_summary/monthly/2009-08

http://example.com/cdmi_domains/domain/cdmi_domain_summary/monthly/2009-10

…

http://example.com/cdmi_domains/domain/cdmi_domain_summary/yearly/

http://example.com/cdmi_domains/domain/cdmi_domain_summary/yearly/2009

http://example.com/cdmi_domains/domain/cdmi_domain_summary/yearly/2010

…
```

All points in time and duration, unless otherwise specified, are in the ISO-8601 extended representation (YYYY-MM-DDThh:mm:ss,ssssss). Components of the time representation with finer granularity may be omitted, if desired.

The "cumulative" summary data object covers the entire time period, from the time the domain is created to the time it is accessed. Each data object at the daily, monthly, and yearly level contains domain summary information for the time period specified, bounded by domain creation time and access time.

If a time period extends earlier than the domain creation time, the summary information includes the time from when the domain was created until the end of the time period. For example, if a domain was created on July 4, 2009, at noon, the daily summary "2009-07-04" would contain information from noon until midnight, the monthly summary "2009-07" would contain information from noon on July 4 until midnight on July 31, and the yearly summary "2009" would contain information from noon on July 4 until midnight on December 31.

If a time period starts after the time when the domain was created and ends earlier than the time of access, the summary data object contains complete information for that time period. For example, if a domain was created on July 4, 2009, and on July 10, the "2009-07-06" daily summary data object was accessed, it would contain information for the complete day.

If a time period ends after the current access time, the domain summary data object contains partial information from the start of the time period (or the time the domain was created) until the time of access. For example, if a domain was created on July 4, 2009, and at noon on July 10, the "2009-07-10" daily summary data object was accessed, it would contain information from the beginning of the day until noon.

The information in Table 5 shall be present within the contents of each domain summary object, which is in JSON representation.

Table 5 – Required Contents of Domain Summary Objects

Metadata Name	Description	Source	Permissions
cdmi_domainURI	Domain name corresponding to the domain that is summarized	Server	Read-Only
cdmi_summary_start	An ISO-8601 point in time indicating the start of the time range that the summary information is presenting	Server	Read-Only
cdmi_summary_end	An ISO-8601 point in time indicating the end of the time range that the summary information is presenting	Server	Read-Only
cdmi_summary_objects	The number of objects under management by the domain	Server	Read-Only
cdmi_summary_puts	The number of objects written to the domain	Server	Read-Only
cdmi_summary_gets	The number of objects read from the domain	Server	Read-Only
cdmi_summary_bytes	The number of user-provided bytes of data under management by the domain	Server	Read-Only
cdmi_summary_writes	The number of bytes written to the domain	Server	Read-Only
cdmi_summary_reads	The number of bytes read from the domain	Server	Read-Only

An example of a daily domain summary object is as follows:

```
{
    "cdmi_domainURI" : "/cdmi_domains/MyDomain/",
    "cdmi_summary_start" : "2009-12-10T00:00:00",
    "cdmi_summary_end" : "2009-12-10T23:59:59",
    "cdmi_summary_objects" : "382239734",
    "cdmi_summary_puts" : "234234",
    "cdmi_summary_gets" : "489432",
    "cdmi_summary_bytes" : "334895798347",
    "cdmi_summary_writes" : "7218368343",
    "cdmi_summary_reads" : "11283974933",
    "cdmi_summary_charge" : "4289.23 USD"
}
```

Any of the metadata listed in Table 6 may also be present within each domain summary object.

Table 6 – Optional Metadata in Domain Summary Objects

Metadata Name	Description	Source	Permissions
cdmi_summary_charge	A free-from monetary measurement of the charge for the use of the service to the user of the domain.	Server	Read-Only

If the charge value is provided, the value is for the operational cost (excluding fixed fees) of service already performed and storage and bandwidth already consumed. Pricing of services is handled separately. Domain summary information can be extended by offerings to include additional metadata or domain reports beyond the metadata items standardized here.

10.1.3 Domain Membership

In cloud storage environments, just as domains are often created programmatically, domain user membership and credential mapping also must be populated using such interfaces. By providing access to user membership, this capability enables self-enrollment, automatic provisioning, and other advanced self-service capabilities, either directly through the CDMI standard or through software systems that interface using CDMI.

The domain membership capability provides information about and allows the specification of end users and groups of users that are allowed to access the domain via CDMI and other access protocols. The concept of domain membership is not intended to replace or supplant ACLs, which form the fundamental basis for access control and object/container ownership, but rather to provide a single, unified place to map identities and credentials to principals used by ACLs within the context of a domain. It also provides a place for authentication mappings to external authentication providers, such as LDAP and AD, to be specified.

If supported, a domain membership container named "cdmi_domain_members" will be present under each domain. Like any container, the domain summary container can have standard metadata, such as ACLs that permit access to this information to be restricted.

Within each domain membership container are a series of user objects that are specified through CDMI to define each user known to the domain. These objects are formatted into the following structure:

```
http://example.com/cdmi_domains/domain/

http://example.com/cdmi_domains/domain/cdmi_domain_members/

http://example.com/cdmi_domains/domain/cdmi_domain_members/john_doe

http://example.com/cdmi_domains/domain/cdmi_domain_members/john_smith

…
```

The domain membership container may also contain sub-containers with user data objects. User data objects in these sub-containers are treated the same as user data objects in the domain membership container, and no meaning is inferred from the sub-container name. This is allowed to create different access security relationships for groups of user objects (via container ACLs) and to allow references to common user lists.

Table 7 lists the domain settings that shall be present within each domain membership object:

Table 7 – Required Settings for Domain Member Objects

Metadata Name	Description	Source	Permissions
cdmi_member_enabled	Indicates if the member is enabled or not	Client	Read/Write
cdmi_member_type	The type of member record. Values include "user" and "delegation".	Client	Read/Write
cdmi_member_name	For "user" type member records, this field contains the user name as presented by the client.	Client	Read/Write
cdmi_member_credentials	For "user" type member records, this field contains credentials to be matched against the credentials as presented by the client.	Client	Read/Write
cdmi_member_groups	For "user" type membership records, this field contains a JSON array of group names to which the user belongs.	Client	Read/Write

Table 7 – Required Settings for Domain Member Objects

Metadata Name	Description	Source	Permissions
cdmi_member_principal	For "user" type member records, this field indicates which principal name (used in ACLs) the user is mapped to.	Client	Read/Write
cdmi_member_privileges	For "user" type member records, this field contains a JSON list of special privileges associated with the user. The following privileges are defined: • "administrator" – All ACL access checks are always successful. • "backup_operator" – All read ACL access checks are always successful. • "cross_domain" – Operations specifying a domain other than the domain of the parent object are permitted.	Client	Read/Write
cdmi_delegation_URI	For "delegation" type member records, this field contains the URI of the domain to which the user evaluation should be delegated. External delegations are expressed in the form of ldap:// or ad://, etc.	Client	Read/Write

Multiple parameters are involved in the above operations, some of which are mandatory and some of which are optional. A conforming implementation shall support the mandatory parameters and may support the optional parameters.

An example of a domain membership object for a user is as follows:

```
{
    "cdmi_member_enabled" : "true",
    "cdmi_member_type" : "user",
    "cdmi_member_name" : "John Doe",
    "cdmi_member_credentials" : "p+5/oX1cmExfOIrUxhX1lw==",
    "cdmi_groups" : [
        "users"
    ],
    "cdmi_member_principal" : "jdoe",
    "cdmi_privileges" : [
        "administrator",
        "cross_domain"
    ]
}
```

An example of a domain membership object for a delegation is as follows:

```
{
    "cdmi_member_enabled" : "true",
    "cdmi_member_type" : "delegation",
    "cdmi_member_uri" : "/cdmi_accounts/MyAccount/",

}
```

When an transaction is initiated against a CDMI URI, the domain associated with the object at the URI (as indicated by the domainURI) is used as the authentication context. The user identity and credentials presented as part of the transaction are compared against the domain membership list to determine if the user is authorized within the domain, and to resolve the user's principal. If resolved, the principal is then evaluated against the object's ACL to determine if the transaction is permitted.

When evaluating members within a domain, delegations are evaluated first, in any order, followed by user records, in any order. If there is at least one matching record and none of the matching records indicate that the user is disabled, the user is considered to be a member of the domain.

When a sub-domain is initially created, the membership container contains one member record, a delegation, where the delegation URI is set to the URI of the parent domain.

10.1.4 Domain Object Representations

The representations in this section are shown using JSON notation. A conforming implementation shall support the mandatory parameters and may support the optional parameters. The parameter fields may be specified or returned in any order. Both clients and servers shall support JSON representation.

10.2 Create a Domain Object (CDMI Content Type)

Synopsis:

Creates a new domain at the specified URI.

```
PUT <root URI>/cdmi_domains/<DomainName>/<NewDomainName>
```

- <root URI> is the path to the CDMI cloud.
- <DomainName> is zero or more intermediate domains that already exist.
- <NewDomainName> is the name specified for the domain to be created.

Once created, the container can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when creating a new domain:

- Support for the ability to create a new domain object is indicated by the presence of the "cdmi_domain_create " capability in the parent container.
- If the new domain object is a copy of an existing domain object, support for the ability to copy is indicated by the presence of the "cdmi_copy_domain" capability in the source domain.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.domain+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.domain+json"	Mandatory

Header	Type	Value	Mandatory/Optional
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory
X-CDMI-NoClobber	Header String	"true". Do not overwrite an existing queue object. If this header element is present and set to "true", it is an error for this operation to proceed. An update should be done instead.	Optional

Request Message Body:

Name	Type	Description	Mandatory/Optional
metadata	JSON Object	Metadata for the domain. If this field is included when copying a domain object, the value provided shall be replace the metadata from the source URI. If this field is not specified, an empty JSON object ("{}") will be assigned as the field value.	Optional
copy	JSON String	URI of a CDMI domain that will be copied into the new domain, including all child domains and membership from the source domain.	Optional*
enabled	JSON String	"true" or "false". The enable state of the domain. If "true", the domain is enabled, and if "false", the domain is disabled. If this field is omitted, the domain is created with a value of "true".	Optional

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.domain+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the domain as specified in the request.	Mandatory
objectID	JSON String	Object ID of the domain	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain. A domain object is always owned by itself.	Mandatory

Name	Type	Description	Mandatory/Optional
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
metadata	JSON Object	Metadata for the domain. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory
enabled	JSON String	The enable state of the domain	Mandatory
childrenrange	JSON String	The range of the children returned in the children field.	Mandatory
children	JSON Array	Names of the children domains in the domain. Child containers end with "/".	Mandatory

Response Status:

HTTP Status	Description
201 Created	New domain object was created
304 Not Modified	The operation conflicts because the domain already exists and the X-CDMI-NoClobber header element was set to "true"
400 Bad Request	Invalid parameter or field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
409 Conflict	The domain name already exists

Example Request:

PUT to the domain URI the domain name and metadata

```
PUT /cdmi_domains/MyDomain HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.domain+json
Content-Type: application/vnd.org.snia.cdmi.domain+json
X-CDMI-Specification-Version: 1.0
{
    "metadata" : {

    }
}
```

The response looks like:

```
HTTP/1.1 201 Created
Content-Type: application/vnd.org.snia.cdmi.domain+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/cdmi_domains/MyDomain",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/cdmi_domains",
    "domainURI" : "/cdmi_domains/MyDomain",
    "capabilitiesURI" : "/cdmi_capabilities/Domain",
    "metadata" : {

    },
    "enabled" : "true",
    "childrenrange" : "1-2",
    "children" : [
        "cdmi_domain_summary/",
        "cdmi_domain_membership/"
    ]
}
```

10.3 Read a Domain Object (CDMI Content Type)

Synopsis:

Reads from an existing domain at the specified URI.

```
GET <root URI>/cdmi_domain/<DomainName>/<TheDomainName>
GET <root URI>/cdmi_domain/<DomainName>/
   <TheDomainName>?<fieldname>;<fieldname>;...
GET <root URI>/cdmi_domain/<DomainName>/<TheDomainName>?children:<range>;...
GET <root URI>/cdmi_domain/<DomainName>/<TheDomainName>?metadata:<prefix>;...
```

- <root URI> is the path to the CDMI cloud.
- <DomainName> is zero or more parent domains.
- <TheDomainName> is the name specified for the domain to be read from.
- <fieldname> is the name of a field from the response message body.
- <range> is a numeric range within the list of children.
- <prefix> is a matching prefix that returns all metadata items that start with the prefix value.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when reading an existing domain:

- Support for the ability to read the metadata of an existing domain object is indicated by the presence of the "cdmi_read_metadata" capability in the specified domain.
- Support for the ability to list the children of an existing domain object is indicated by the presence of the "cdmi_list_children" capability in the specified domain.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.domain+json"	Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.object+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.domain+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the domain as specified in the request.	Mandatory
objectID	JSON String	Object ID of the domain	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain. A domain object is always owned by itself.	Mandatory
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
metadata	JSON Object	Metadata for the domain. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory

Name	Type	Description	Mandatory/Optional
enabled	JSON String	The enable state of the domain.	Mandatory
childrenrange	JSON String	The range of the children returned in the children field.	Mandatory
children	JSON Array	The children of the domain. Sub-domains end with "/".	Mandatory

If individual fields are specified in the GET request, only these fields are returned in the result body. Optional fields that are requested but do not exist are omitted from the result body. Requesting fields not defined in the standard result in a 400 Bad Request HTTP status code.

Response Status:

HTTP Status	Description
200 OK	Domain contents in response
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid Parameter or Field Names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	A domain was not found at the specified URI.
406 Not Acceptable	The server is unable to provide the object in the content-type specified in the Accept header.

Example Request:

GET to the domain URI to read all the fields of the domain

```
GET /MyDomain HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.domain+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.domain+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/cdmi_domains/MyDomain",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/cdmi_domains",
    "domainURI" : "/cdmi_domains/MyDomain",
    "capabilitiesURI" : "/cdmi_capabilities/Domain",
    "metadata" : {

    },
    "enabled" : "true",
    "childrenrange" : "0-1",
    "children" : [
        "cdmi_domain_summary/",
        "cdmi_domain_membership/"
    ]
}
```

Example Request:

GET to the domain URI to read all the parentURI and children of the domain

```
GET /MyDomain?parentURI;children HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.domain+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.domain+json
X-CDMI-Specification-Version: 1.0
{
    "parentURI" : "/cdmi_domains",
    "children" : [
        "cdmi_domain_summary/",
        "cdmi_domain_membership/"
    ]
}
```

Example Request:

GET to the domain URI to read the first two children of the domain

```
GET /MyDomain?childrenrange;children:0-1 HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.domain+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.domain+json
X-CDMI-Specification-Version: 1.0
{
    "childrenrange" : "0-1",
    "children" : [
        "cdmi_domain_summary/",
        "cdmi_domain_membership/"
    ]
}
```

10.4 Update a Domain (CDMI Content Type)

Synopsis:

Updates an existing domain at the specified URI.

```
PUT <root URI>/cmdi_domains/<DomainName>/<TheDomainName>
PUT <root URI>/cmdi_domains/<DomainName>/<TheDomainName>?metadata
```

- <root URI> is the path to the CDMI cloud.
- <DomainName> is zero or more parent domains.
- <TheDomainName> is the name specified for the domain to be updated.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>, and an update shall not result in a change to the Object ID.

Capabilities:

The following capabilities describe the supported operations that can be performed when updating an existing domain:

- Support for the ability to modify the metadata of an existing domain object is indicated by the presence of the "cdmi_modify_metadata" capability in the specified domain.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.domain+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.domain+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory
X-CDMI-MustExist	Header String	"true". Fail updates if the domain does not exist. If this header element exists and is set to "true", it is an error for the domain to not already exist.	Optional

Request Message Body:

Name	Type	Description	Mandatory/Optional
metadata	JSON Object	Metadata for the container. If present, this replaces the existing metadata. See Chapter 16, “Metadata” for a further description of metadata.	Optional
enabled	JSON String	The enable state of the domain. If "true", the domain is enabled, and if "false", the domain is disabled.	Optional

Response Headers:

Header	Type	Value	Mandatory/Optional
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Domain was updated
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request.
404 Not Found	An update was attempted on a domain that does not exist, and the X-CDMI-MustExist header element was set to "true".
409 Conflict	The operation conflicts with a non-CDMI access protocol lock or could cause a state transition error on the server.

Example Request:

PUT to the domain URI to set new field values

```
PUT /cdmi_domains/myDomain HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.domain+json
Content-Type: application/vnd.org.snia.cdmi.domain+json
X-CDMI-Specification-Version: 1.0
{
    "enabled" : "true",
    "metadata" : {
        "test" : "value"
    }
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

Example Request:

PUT to the domain URI to disable a domain

```
PUT /cdmi_domains/myDomain?enable HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.domain+json
Content-Type: application/vnd.org.snia.cdmi.domain+json
X-CDMI-Specification-Version: 1.0
{
    "enabled" : "false"
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

10.5 Delete a Domain (CDMI Content Type)

Synopsis:

Deletes an existing domain, and all contained children domains under the specified URI.

`DELETE <root URI>/cdmi_domains/<DomainName>/<TheDomainName>`

- <root URI> is the path to the CDMI cloud.
- <DomainName> is zero or more parent domains.
- <TheDomainName> is the name specified for the domain to be deleted.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when deleting an existing container:

- Support for the ability to delete an existing data object is indicated by the presence of the "cdmi_domain_delete " capability in the specified domain.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.domain+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.domain+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

Name	Type	Description	Mandatory/Optional
newDomain	JSON String	The new domainURI that will own the objects being deleted, including the objects that the domain owns and any children domains. This shall be a valid domain URI.	Mandatory

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Domain was successfully deleted.
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request.
404 Not Found	The resource specified was not found.
409 Conflict	The domain cannot be deleted (may be immutable), or the specified newDomain URI is invalid or unusable.

Example Request:

DELETE to the domain URI

```
DELETE /cdmi_domains/MyDomain HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.domain+json
Content-Type: application/vnd.org.snia.cdmi.domain+json
X-CDMI-Specification-Version: 1.0
{
    "newDomain" : "/cdmi_domains/secondDomain"
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

11 Queue Objects

11.1 Overview

Queues are a special class of container object and are used to provide first-in, first-out access when storing and retrieving data. A queue writer PUTs objects to the queue, and a queue reader GETs objects from the queue, acknowledging the receipt of the last object that it received. Queuing provides a simple mechanism for one or more writers to send data to a single reader in a reliable way. If supported by the cloud storage system, cloud clients create the queue objects by using the same mechanism used to create data objects.

Every queue object has a parent object from which the queue object inherits data system metadata. For example, the "receipts.queue" queue object stored at "http://cloud.example.com/finance/receipts.queue" would inherit data system metadata from its parent container, “finance”.

11.1.1 Notification Queues

Notification queues allow CDMI clients to efficiently discover what changes have occurred to the system. As queue data is persistent, no session state needs to be retained by the client, and clients can operate in a disconnected and casual manner. For example, an SRM application might use notification queues to keep its databases current without having to do full scans of a container.

This pattern for inter-system communication applies to a wide range of workflow and system integration problems. Other examples include search indexing, where each time a new object is created, an object is modified or deleted, and it can find out what changes have occurred and update the search index.

When creating a notification queue, the metadata described in Table 8 shall be provided.

Table 8 – Required Data for a Notification Queue

Metadata Name	Description	Source	Permissions
cdmi_queue_type	The queue type indicates how the cloud storage system should manage the queue object. The type of "cdmi_notification_queue" is defined for notification queues.	Client	Read/Write
cdmi_notification_events	Contains a JSON array that indicates which events generate notifications. • Values can be: cdmi_create_processing, cdmi_create_complete, cdmi_read, cdmi_modify_processing, cdmi_modify_complate, cdmi_rename, cdmi_copy, cdmi_reference, cdmi_delete, cdmi_export, cdmi_snapshot <zero or more vendor events> • If cdmi_copy is not included but cdmi_read is, a read notification will be generated for each copy operation.	Client	Read/Write

An example of the metadata associated with a notification queue is as follows:

```
{
    "metadata" : {
        "cdmi_queue_type" : "cdmi_notification_queue",
        "cdmi_notification_events" : [
            "cdmi_create_complete",
            "cdmi_read",
            "cdmi_modify"
        ],
        "cdmi_scope_specification" : [
            {
                "metadata" : "cdmi_size",
                "operator" : ">",
                "value" : "100000"
            }
        ],
        "cdmi_returned_results" : [
            "cdmi_event",
            "cdmi_result",
            "cdmi_objectID",
            "cdmi_size"
        ]
    }
}
```

When performing a GET from a notification queue, the following JSON-encoded data will be returned for each notification entry:

Field Name	Data Type	Description	Source
cdmi_results_metadata	String Array	The asked-for selected return items, as specified in the query.	Client
cdmi_notification_results	String Array	A string array of returned information for the event that triggered the notification.	Client

An example of notification results is as follows:

```
{
    "cdmi_results_metadata" : [
        "cdmi_event",
        "cdmi_result",
        "cdmi_objectID",
        "cdmi_size"
    ],
    "cdmi_query_results" : [
        "cdmi_create_complete",
        "successful",
        "AABwbQAQcPHaGbXdQ8x9xw==",
        "2398733"
    ]
}
```

Notifications will only be generated if the user who is creating the notification queue has sufficient rights to see and read the object.

11.1.2 Logging Queues

Logging queues allow CDMI clients to obtain detailed logging information about the actions related to the operation of a CDMI storage system. As queue data is persistent, no session state needs to be retained by the client, and clients can operate in a disconnected and casual manner. For example, a logging analysis application might use logging queues to obtain information about actions performed to a cloud, and it may receive only logging messages that are relevant to a domain or set of objects.

Logging queues differ from notification queues in that the information provided is at a much more detailed level than notifications and is typically restricted to a smaller, more privileged, subset of clients.

When creating a logging queue, the metadata described in Table 9 shall be provided.

Table 9 – Required Metadata for a Logging Queue

Metadata Name	Description	Source	Permissions
cdmi_queue_type	The queue type indicates how the cloud storage system should manage the queue object. The type of "cdmi_logging_queue" is defined for notification queues.	Client	Read/Write
cdmi_logging_class	Contains a JSON array that indicates which log messages are to be enqueued. Values can be cdmi_object_logging, cdmi_datasystem_logging, cdmi_security_logging	Client	Read/Write

cdmi_scope_specification	Contains a JSON array of JSON objects, each which indicates a logging scope based on path and domain.
	An example of a path scope is:
	`[`
	`    {`
	`        "metadata" : "cdmi_path",`
	`        "operator" : "starts",`
	`        "value" : "/MyContainer/"`
	`    }`
	`]`
	An example of a domain scope is:
	`[`
	`    {`
	`        "metadata" : "cdmi_domain",`
	`        "operator" : "=",`
	`        "value" : "/cdmi_domains/`
	`   MyDomain/"`
	`    }`
	`]`
	If a path or domain scope is not specified, logging for all domains and all paths will be included.
		Client	Read/Write

An example of the metadata associated with a logging queue is as follows:

```
{
    "metadata" : {
        "cdmi_queue_type" : "cdmi_logging_queue",
        "cdmi_logging_class" : [
            "cdmi_object_logging"
        ],
        "cdmi_scope_specification" : [
            {
                "metadata" : "cdmi_domain",
                "operator" : "=",
                "value" : "/cdmi_domains/MyDomain/"
            }
        ]
    }
}
```

When performing a GET from a logging queue, an independent log entry in JSON format will be returned.

11.1.3 Query Queues

If supported, offerings permit the creation of query queues that allow queries to be performed on the content stored.

Query queues allow CDMI clients to efficiently discover what content matches a given set of metadata query criteria or full-content search criteria. Clients PUT a query specification into the queue, including a URI to a query results data object to be created. The cloud storage query engine will then initiate a query, creating a new query results object in the designated location. As query results are found, they are added to the query results data object, and when the query is complete, the state of the query results data object is changed to indicate that the query has completed.

External query engines can be easily integrated into a cloud system by using CDMI to read the contents of the query queue, then performing the queries on behalf of the user who posted the query.

When creating a query queue, the metadata described in Table 10, “Required Metadata for a Query Queue” shall be provided.

Table 10 – Required Metadata for a Query Queue

Metadata Name	Description	Source	Permissions
cdmi_queue_type	The queue type indicates how the cloud storage system should manage the queue object. The type of "cdmi_query_queue" is defined for query queues.	Client	Read/Write

An example of the metadata associated with a query queue is as follows:

```
{
    "metadata" : {
        "cdmi_queue_type" : "cdmi_query_queue"
    }
}
```

When performing a query, the metadata described in Table 11 shall be PUT to a queue.

Table 11 – Required Query Metadata PUTS to a Queue

Metadata Name	Data	Description	Source
cdmi_query_name	JSON String	The name of the query, as specified by the client.	Client
cdmi_query_uri	JSON String	The URI where the query results will be stored. If there is not an object at this URI, a new data object will be created with the value of the data object equal to the results of the query. If there is a queue at this URI, the results of the query will be enqueued into the queue.	Client
cdmi_query_domains	JSON Array	Contains a list of domains that indicates the scope of the query. Only objects and containers within the domains specified will generate query results. If not specified, all domains will be considered valid for the purposes of the search.	Client

cdmi_query_specification	JSON Array of JSON Objects	Metadata query items, where the metadata name is the metadata item to be queried and the value is a query string.
		An example is:
		`[`
		`    {`
		`        "metadata": "cdmi_size",`
		`        "operator" : ">",`
		`        "value" : "1000000"`
		`    }`
		`]`
		Which only matches objects that are larger than 1 MB.
		The following operators are defined:
		=, != >, <, >=, <=, like, starts, ends, contains.
		In addition to metadata scope, query results can be restricted based on path and domain.
		An example of a path scope is:
		`[`
		`    {`
		`        "metadata" : "cdmi_path",`
		`        "operator" : "starts",`
		`        "value" : "/MyContainer/"`
		`    }`
		`]`
		An example of a domain scope is:
		`[`
		`    {`
		`        "metadata" : "cdmi_domain",`
		`        "operator" : "=",`
		`        "value" : "/cdmi_domains/MyDomain/"`
		`    }`
		`]`
		If no path or domain scopes are specified, matching objects at all paths and domains will be returned.
			Client

Table 11 – Required Query Metadata PUTS to a Queue

Metadata Name	Data	Description	Source
cdmi_returned_results	JSON Array	Contains a tag list that indicates which metadata and other parameters associated with the objects are returned for each object that matches the query. Values can be all, OID, <zero or more additional CDMI, user and vendor metadata names>. If all is specified, then all metadata items will be returned in each result.	Client

A query result data object will be created in the specified URI location with an ACL that permits the user who posted the query to be able to read and delete the query result data object.

An example of a data value posted into a query queue is as follows:

```
{
    "metadata" : {
        "cdmi_query_name" : "test",
        "cdmi_query_uri" : "/sandbox/testing/testqueryresults",
        "cdmi_query_scope" : [
            "/sandbox/"
        ],
        "cdmi_query_specification" : [
            {
                "metadata" : "cdmi_size",
                "operator" : ">",
                "value" : "100000"
            },
            {
                "metadata" : "cdmi_path",
                "operator" : "starts",
                "value" : "/MyContainer/"
            }
        ],
        "cdmi_returned_results" : [
            "cdmi_objectID",
            "cdmi_size"
        ]
    }
}
```

Table 12, “Required Value of a Query Result Data Object” describes the JSON-encoded data that will be present in the value of a query result data object.

Table 12 – Required Value of a Query Result Data Object

Field Name	Data Type	Description	Source
cdmi_query_name	JSON String	The name of the query, as specified by the client in the request.	Client
cdmi_query_count	JSON String	The number of objects or containers that match the query specification.	Client

Table 12 – Required Value of a Query Result Data Object

Field Name	Data Type	Description	Source
cdmi_results_metadata	JSON Array	The asked for selected return items, as specified in the query.	Client
cdmi_query_results	JSON Array of JSON Arrays	A string array of each object's selected return items, as specified in the query.	Client

An example of a query results value is as follows:

```
{
    "cdmi_query_name" : "test",
    "cdmi_query_count" : "2",
    "cdmi_results_metadata" : [
        "cdmi_objectID",
        "cdmi_size"
    ],
    "cdmi_query_results" : [
        [
            "AABwbQAQcPHaGbXdQ8x9xw==",
            "2398733"
        ],
        [
            "AABwbQAQYiNPRBi+Ky8KDQ==",
            "1394839"
        ]
    ]
}
```

Results will only be included in a query if the user who enqueues the query has sufficient rights to see and read the object.

11.1.4 Queue Object Metadata

Queue object metadata can also include arbitrary user-supplied metadata and data system metadata, as specified in Chapter 16, “Metadata”.

11.1.5 Queue Object Addressing

Each queue object is addressed via one or more unique URIs, and all operations may be performed through any of these URIs.

11.1.6 Queue Object Representations

The representations in this section are shown using JSON notation. A conforming implementation shall support the mandatory parameters and may support the optional parameters. The parameter fields may be specified or returned in any order. Both clients and servers shall support JSON representation.

11.2 Create a Queue Object (CDMI Content Type)

Synopsis:

Creates a new queue object at the specified URI.

```
PUT <root URI>/<ContainerName>/<QueueName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers that already exist.
- <QueueName> is the name specified for the queue object to be created.

Once created, the object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Delayed Completion of Create:

On a create operation for a queue, the server may return a response of "202 Accepted". In this case, the queue is in the process of being created. This response is particularly useful for long-running operations, for instance, for copying a large data object from a source URI. Such a response has the following implications:

- The server returns an object identifier along with the "202 Accepted". With "202 Accepted", the server implies that the following checks have passed:
  - — User authorization for creating the queue object
  - — User authorization for read access to any source object for move, copy, serialize, or deserialize
  - — Availability of space to create the queue or at least enough space to create a URI to report an error

Future accesses to the URI created (or the object ID) will succeed modulo any delays due to use of eventual consistency.

The client performs GET operations to the URI to track the progress of the operation. In particular, the server returns two fields in its response body to indicate progress:

- A completionStatus text field contains either "Processing", "Complete", or an error message
- An optional percentComplete field that indicates the percentage to which the last PUT has completed (0 to 100)

GET does not return any value for the object when completionStatus is not "Complete".

When the final result of the create operation is an error, the URI is created with the completionStatus field set to the error message. It is the client's responsibility to delete the URI after the error has been noted.

Capabilities:

The following capabilities describe the supported operations that can be performed when creating a new queue object:

- Support for the ability to create a new queue object is indicated by the presence of the "cdmi_create_queue" capability in the parent container.

- If the new queue object is a reference of an existing queue object, support for the ability to create the reference is indicated by the presence of the "cdmi_create_reference" capability in the parent container.
- If the new queue object is a copy of an existing queue object, support for the ability to copy is indicated by the presence of the "cdmi_copy_queue" capability in the patent container.
- If the new queue object is the destination of a move, support for the ability to move the queue object is indicated by the presence of the "cdmi_move_queue" capability in the parent container.
- If the new queue object is the destination of a deserialize operation, support for the ability to deserialize the source data object is indicated by the presence of the "cdmi_deserialize_queue" capability in the parent container.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory
X-CDMI-NoClobber	Header String	"true". Do not overwrite an existing queue object. If this header element is present and set to "true", it is an error for this operation to proceed. An update should be done instead.	Optional

Request Message Body:

Name	Type	Description	Mandatory/Optional
metadata	JSON Object	Metadata for the queue object. If this field is included when deserializing, serializing, copying, or moving a queue object, the value provided shall be replace the metadata from the source URI. This field shall not be included when referencing a queue object. If this field is not specified, an empty JSON object ("{}") will be assigned as the field value.	Optional
domainURI	JSON String	URI of the owning domain. If different from the parent domain, the user must have the "cross_domain" privilege. If not specified, the parent domain will be used.	Optional
deserialize	JSON String	URI of a serialized CDMI data object that will be deserialized to create the new queue object.	Optional*
copy	JSON String	URI of a CDMI queue object that will be copied into the new queue object.	Optional*

Name	Type	Description	Mandatory/Optional
move	JSON String	URI of a CDMI queue object that will be copied into the new queue object. When the copy is successfully completed, the queue object at the source URI is removed.	Optional*
reference	JSON String	URI of a CDMI queue object to which a reference points. No other fields may be specified when creating a reference.	Optional*

*Only one of these parameters shall be specified in any given operation and is not persisted.

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the queue as specified in the request.	Mandatory
objectID	JSON String	Object ID of the object	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain	Mandatory
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
completionStatus	JSON String	A string indicating if the object is still in the process of being created, and once the operation is complete, if it was created successfully or an error occurred. The value shall be the string "Processing", the string "Complete", or an error message.	Mandatory
percentComplete	JSON String	The value shall be an integer numeric value from 0 through 100.	Optional

Name	Type	Description	Mandatory/Optional
metadata	JSON Object	Metadata for the queue object. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory
queueValues	JSON String	The number of values enqueued in the queue.	Mandatory

Response Status:

HTTP Status	Description
201 Created	New queue object was created
202 Accepted	Queue object is in the process of being created. Investigate completionStatus and percentComplete parameters to determine the current status of the operation
304 Not Modified	The operation conflicts because the queue object already exists and the X-CDMI-NoClobber header element was set to "true".
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request.
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

PUT to the container URI the queue object name and contents

```
PUT /MyContainer/MyQueue HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.queue+json
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
{
    "metadata" : {

    }
}
```

The response looks like:

```
HTTP/1.1 201 Created
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/MyQueue",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI " : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/Queue",
    "completionStatus" : "Complete",
    "metadata" : {

    },
    "queuevalues" : "0"
}
```

11.3 Read a Queue Object (CDMI Content Type)

Synopsis:

Reads from an existing queue object at the specified URI.

```
GET <root URI>/<ContainerName>/<QueueName>
GET <root URI>/<ContainerName>/<QueueName>?<fieldname>;<fieldname>;...
GET <root URI>/<ContainerName>/<QueueName>?value:<range>
GET <root URI>/<ContainerName>/<QueueName>?metadata:<prefix>;...
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <QueueName> is the name of the queue object to be read from.
- <fieldname> is the name of a field from the response message body.
- <range> is a byte range within the queue element value field.
- <prefix> is a matching prefix that returns all metadata items that start with the prefix value.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when reading an existing queue object:

- Support for the ability to read the metadata of an existing queue object is indicated by the presence of the "cdmi_read_metadata" capability in the specified queue.
- Support for the ability to read the value of an existing queue object is indicated by the presence of the "cdmi_read_value" capability in the specified queue.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.queue+json"	Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.object+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the queue object as specified in the request.	Mandatory
objectID	JSON String	Object ID of the object	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
domainURI	JSON String	URI of the owning domain	Mandatory
capabilitiesURI	JSON String	URI to the capabilities for the object. The capabilities URI returned is based on the object type and requested data system metadata fields.	Mandatory
completionStatus	JSON String	A string indicating if the object is still in the process of being created, and once the operation is complete, if it was created successfully or an error occurred. The value shall be the string "Processing", the string "Complete", or an error message.	Mandatory

Name	Type	Description	Mandatory/Optional
percentComplete	JSON String	The value shall be an integer numeric value from 0 through 100.	Optional
metadata	JSON Object	Metadata for the queue object. This field includes any user and data system metadata specified in the request body metadata field, along with storage system metadata generated by the cloud storage system. See Chapter 16, “Metadata” for a further description of metadata.	Mandatory
queueValues	JSON String	The number of items currently enqueued into the queue.	Mandatory
mimetype	JSON String	Mime type of the oldest queue value. This field shall only be provided when completionStatus is "Complete", and when there are one or more values enqueued.	Optional
valuerange	JSON String	The range of bytes of the value returned in the value field. This field shall only be provided when completionStatus is "Complete", and when there are one or more values enqueued.	Optional
value	JSON String	Value of the oldest enqueued item. This field will only be provided when completionStatus is "Complete" and when there are one or more values enqueued.	Optional

If individual fields are specified in the GET request, only these fields are returned in the result body. Optional fields that are requested but do not exist are omitted from the result body. Requesting fields not defined in the standard result in a 400 Bad Request HTTP status code.

Response Status:

HTTP Status	Description
200 OK	Valid response is enclosed
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	A queue object was not found at the specified URI.
406 Not Acceptable	The server is unable to provide the object in the content-type specified in the Accept header.

Example Request:

GET to the queue object URI to read all fields of the queue object

```
GET /MyContainer/MyQueue HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.queue+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/MyQueue",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/Queue",
    "completionStatus" : "Complete",
    "metadata" : {

    },
    "queueValues" : "0"

}
```

Example Request:

GET to the queue object URI to read the value and queue items of the queue object

```
GET /MyContainer/MyQueue?value;queueValues HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.queue+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
{
    "value" : "First Enqueued Item",
    "queueValues" : "1"
}
```

Example Request:

GET to the queue object URI to read the first five bytes of the value of the queue object

```
GET /MyContainer/MyQueue?value:0-5 HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.object+json
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
{
    "value" : "First"
}
```

11.4 Update a Queue Object (CDMI Content Type)

Synopsis:

Updates an existing queue at the specified URI.

```
PUT <root URI>/<ContainerName>/<QueueName>
PUT <root URI>/<ContainerName>/<QueueName>?metadata
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <QueueName> is the name of the queue to be updated.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>, and an update shall not result in a change to the Object ID.

Capabilities:

The following capabilities describe the supported operations that can be performed when updating an existing queue object:

- Support for the ability to modify the metadata of an existing queue object is indicated by the presence of the "cdmi_modify_metadata" capability in the specified queue.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.queue +json"	Mandatory

Header	Type	Value	Mandatory/Optional
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory
X-CDMI-MustExist	Header String	"true". Fail updates if the object does not exist. If this header element exists and is set to "true", it is an error for the object to not already exist.	Optional

Request Message Body:

Name	Type	Description	Mandatory/Optional
metadata	JSON Object	Metadata for the queue object. If present this replaces the existing metadata. See Chapter 16, “Metadata” for a further description of metadata.	Optional
domainURI	JSON String	URI of the owning domain. If different from the parent domain, the user must have the “cross_domain” privilege. If not specified, the parent domain will be used.	Optional

Response Headers:

Header	Type	Value	Mandatory/Optional
Location	Header String	The server shall respond with the URI that the reference points to if the object is a reference.	Mandatory

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	New metadata and/or content accepted
302 Found	The URI is a reference to another URI
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	An update was attempted on an object which does not exist, and the X-CDMI-MustExist header element was set to "true".
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

PUT to the queue object URI to set new metadata

```
PUT /MyContainer/MyQueue HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.queue+json
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
{
    "metadata" : {

    }
}
```

The response looks like:

```
HTTP/1.1 200 OK
```

11.5 Delete a Queue Object (CDMI Content Type)

Synopsis:

Deletes an existing queue object and all enqueued values at the specified URI.

```
DELETE <root URI>/<ContainerName>/<QueueName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <QueueName> is the name of the queue object to be deleted.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when deleting an existing data object:

- Support for the ability to delete an existing queue object is indicated by the presence of the "cdmi_delete_queue" capability in the specified queue.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Queue object was successfully deleted
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The resource specified was not found
409 Conflict	The queue object cannot be deleted (may be immutable)

Example Request:

DELETE to the queue URI

```
DELETE /MyContainer/MyQueue HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.queue+json
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
```

11.6 Enqueue a New Queue Value (CDMI Content Type)

Synopsis:

Enqueues a new data value in an existing Queue at the specified container URI.

```
POST <root URI>/<ContainerName>/<QueueName>
```

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers that already exist.
- <QueueName> is the name of the queue object to be read from.

Capabilities:

The following capabilities describe the supported operations that can be performed when enqueuing a new value into an existing queue object:

- Support for the ability to modify the value of an existing queue object is indicated by the presence of the "cdmi_modify_value" capability in the specified queue.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

Name	Type	Description	Mandatory/Optional
mimetype	JSON String	Mime type of the data contained within the value field of the data object. This field shall not be included when copying or moving a data object. If this field is not specified, the value of "text/plain" will be assigned as the field value.	Optional
copy	JSON String	URI of a CDMI data object or queue from which the value will be copied and enqueued.	Optional*
move	JSON String	URI of a CDMI data object or queue from which the value will be enqueued, then removing the data object or queue value at the source URI upon the successful completion of the enqueue.	Optional*
value	JSON String	JSON-encoded data. If this field is not included, an empty JSON String ("") will be assigned as the field value. Binary data must be escaped as per the JSON escaping rules described in [RFC4627].	Optional*

*Only one of these parameters shall be specified in any given operation.

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.dataobject+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory

Response Message Body: N/A

Response Status:

HTTP Status	Description
201 Created	New queue value was enqueued
400 Bad Request	Invalid parameter in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The specified container URI does not exist.
409 Conflict	The operation conflicts with a non-CDMI access protocol lock, or could cause a state transition error on the server.

Example Request:

POST to the queue URI a new value

```
POST /MyContainer/MyQueue HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "mimetype" : "text/plain",
    "value" : "This is the Value of this Data Object"
}
```

The response looks like:

```
HTTP/1.1 201 Created
```

Example Request:

POST to the queue URI to copy an existing value

```
POST /MyContainer/MyQueue HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "copy" : "/MyContainer/MyDataObject"
}
```

The response looks like:

```
HTTP/1.1 201 Created
```

Example Request:

POST to the queue URI to transfer a value from another queue

```
POST /MyContainer/MyQueue HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.dataobject+json
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "move" : "/MyContainer/FirstQueue"
}
```

The response looks like:

```
HTTP/1.1 201 Created
```

11.7 Delete a Queue Value (CDMI Content Type)

Synopsis:

Deletes the oldest enqueued value in an existing queue object at the specified URI.

`DELETE <root URI>/<ContainerName>/<QueueName>?value`

- <root URI> is the path to the CDMI cloud.
- <ContainerName> is zero or more intermediate containers.
- <QueueName> is the name of the queue object to be deleted.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when deleting an existing data object:

- Support for the ability to modify the value of an existing queue object is indicated by the presence of the "cdmi_modify_value" capability in the specified queue.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
Content-Type	Header String	"application/vnd.org.snia.cdmi.queue+json"	Mandatory
X-CDMI-Specification-Version	Header String	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

N/A

Response Message Body:

N/A

Response Status:

HTTP Status	Description
200 OK	Queue object was successfully deleted
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request
404 Not Found	The resource specified was not found
409 Conflict	The queue object cannot be deleted (may be immutable)

Example Request:

DELETE to the queue URI value to access the next enqueued value

```
DELETE /MyContainer/MyQueue?value HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.queue+json
Content-Type: application/vnd.org.snia.cdmi.queue+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
```

12 Capability Objects

12.1 Overview

Capability objects are a special class of container object that allow a CDMI client to discover what subset of the CDMI standard is implemented by a CDMI provider.

For each URI in a CDMI system, the set of interactions that the system is capable of performing against that URI are described by the presence of named "capabilities". Each capability present for a given URI indicates what functionality the cloud storage system will allow against that URI. Capabilities are always static.

It is important to note that capabilities may differ from the operations permitted by an Access Control List (ACL) associated with a given URI—for example, a read-only cloud may not permit write access to a container or object, despite the presence of an ACL allowing write access.

Cloud clients can use capabilities to discover what operations are supported. If an operation is attempted to be performed against a CDMI object that does not have a corresponding capability, an HTTP 405 status code shall be returned to the client. All CDMI-compliant cloud storage systems shall implement the ability to list capabilities, but support for all other capabilities is optional.

Every CDMI data object, container domain, and queue must have a capabilitiesURI field that contains a valid URI that points to a capabilities object. Within the capabilities object, the name of each capability confers a specific meaning that has been agreed to between the cloud storage provider and the cloud storage consumer, and the capabilities defined as part of the CDMI standard are described later in this section. Capabilities not listed in this standard shall not begin with the prefix "cdmi_", but are otherwise permitted to allow cloud storage system vendors to add additional capabilities.

The base set of CDMI capabilities are based on the operations defined in the previous sections, with additional cloud-specific capabilities added based on use cases for standard cloud storage. The hierarchy of capabilities (see Figure 8) shows the hierarchy of capabilities in an offering and shows how the capabilitiesURI links data objects and containers into the capabilities tree.

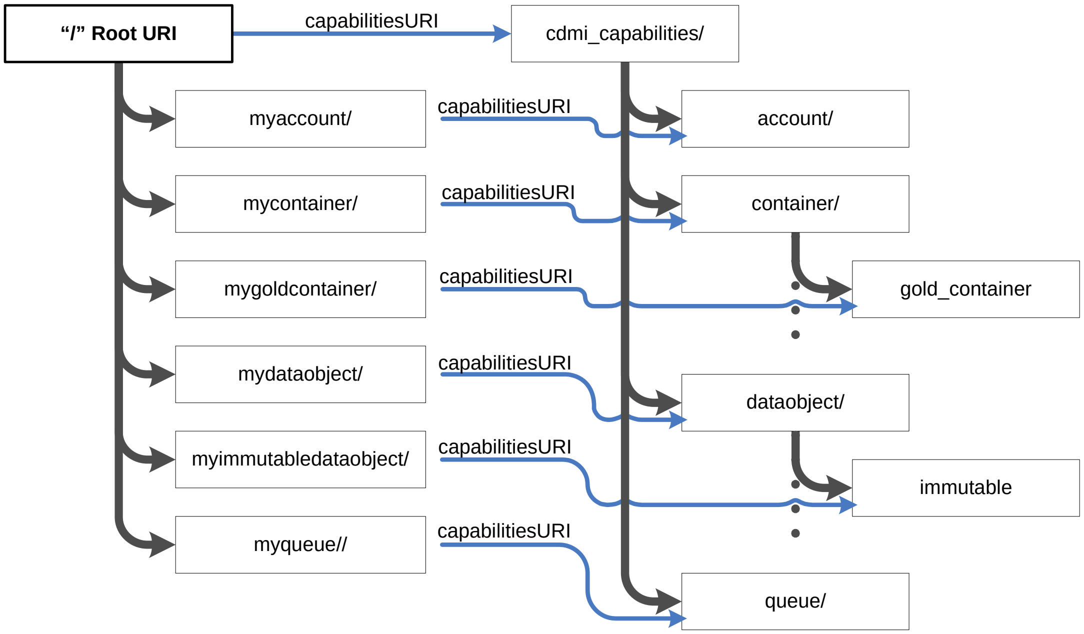


Figure 8 – Hierarchy of Capabilities

The capabilities container within the capabilities tree to which an object is linked is based on the type of the object and the data system metadata fields present in the object. For example, a container with no data system metadata fields specified may map to the "container" capabilities entry.

As an option, a CDMI implementation may map a container to a "gold_container" capabilities entry, if a data system metadata field is present and set to a given value, such as if the "cdmi_data_redundency" field was set to the value of "4". This permits a cloud provider to create profiles of data system metadata fields and values.

Capabilities do not have CDMI metadata.

12.1.1 Cloud Storage System-Wide Capabilities

Table 13, “System-Wide Capabilities” defines the system-wide capabilities in a cloud storage system. These capabilities, which are found in the capabilities object, are referred to by the root URI (root capabilities).

Table 13 – System-Wide Capabilities

Capability	Definition
cdmi_domains	If present and "true", the cloud storage/computing system supports domains. If not present, the "domainURI" field will not be present in response bodies, and the "cdmi_domains" URI will not be present.
cdmi_export_cifs	If present and "true", the cloud storage/computing system supports CIFS exports.
cdmi_export_fc	If present and "true", the cloud storage/computing system supports FC exports.
cdmi_export_fcoe	If present and "true", the cloud storage/computing system supports FCoE exports.
cdmi_export_iscsi	If present and "true", the cloud storage/computing system supports iSCSI exports.
cdmi_export_nfs	If present and "true", the cloud storage/computing system supports NFS protocol exports.
cdmi_export_occi_iscsi	If present and "true", the cloud storage/computing system supports OCCI/ iSCSI exports.
cdmi_export_webdav	If present and "true", the cloud storage/computing system supports WebDAV exports.
cdmi_metadata_maxitems	If present, this capability specifies the maximum number of user-defined metadata items supported by the cloud storage system. If absent, there is no limit placed on the number of user-defined metadata items.
cdmi_metadata_maxsize	If present, this capability specifies the maximum size in bytes of each user-defined metadata item supported by the cloud storage system. If absent, there is no limit placed on the number of user-defined metadata items.
cdmi_notification	If present and "true", the cloud storage system supports notification queues.
cdmi_query	If present and "true", the cloud storage system supports query queues.
cdmi_queues	If present and "true", the cloud storage system supports queue objects.
cdmi_security_audit	If present and "true", the cloud storage system supports audit logging.

Table 13 – System-Wide Capabilities

Capability	Definition
cdmi_security_data_integrity	If present and "true", the cloud storage system supports data integrity/ authenticity.
cdmi_security_encryption	If present and "true", the cloud storage system supports data at-rest encryption.
cdmi_security_https_transport	If present and "true", the cloud storage system supports HTTPS communications.
cdmi_security_immutability	If present and "true", the cloud storage system supports data immutability/ retentions.
cdmi_security_sanitization	If present and "true", the cloud storage system supports data/media sanitization.
cdmi_serialization_json	If present and "true", the cloud storage system supports json as a serialization format.
cdmi_serialization_yaml	If present and "true", the cloud storage system supports yaml as a serialization format.
cdmi_xmlrepresentation	If present and "true", the cloud storage system supports XML representations.

12.1.2 Storage System Metadata Capabilities

Table 14, “Capabilities for Storage System Metadata” defines the capabilities for storage system metadata in a cloud storage system. These capabilities are found in the capabilities objects for domains, data objects, containers, and queues. See Section 16.3, “Support for Storage System Metadata” for a description of these storage system metadata elements.

Table 14 – Capabilities for Storage System Metadata

Capability	Definition
cdmi_size	If present and "true", the cloud storage system will generate a "size" storage system metadata for each stored object.
cdmi_billingsize	If present and "true", the cloud storage system will generate a "billingsize" storage system metadata for each stored object.
cdmi_ctime	If present and "true", the cloud storage system will generate a "ctime" storage system metadata for each stored object.
cdmi_atime	If present and "true", the cloud storage system will generate a "atime" storage system metadata for each stored object.
cdmi_mtime	If present and "true", the cloud storage system will generate a "mtime" storage system metadata for each stored object.
cdmi_acount	If present and "true", the cloud storage system will generate a "acount" storage system metadata for each stored object.
cdmi_mcount	If present and "true", the cloud storage system will generate a "mcount" storage system metadata for each stored object.

Table 14 – Capabilities for Storage System Metadata

Capability	Definition
cdmi_hash	If present, the cloud storage system will generate a "cdmi_value_hash" storage system metadata for each stored object using the algorithm specified in the value of the cdmi_hash capability.
cdmi_acl	If present and "true", the cloud storage system will support ACLs.

12.1.3 Data System Metadata Capabilities

Table 15, “Capabilities for Data System Metadata” defines the capabilities for data system metadata in a cloud storage system. These capabilities are found in the capabilities objects for domains, data objects, containers, and queues. See Section 16.3, “Support for Storage System Metadata” for a description of these data system metadata elements.

Table 15 – Capabilities for Data System Metadata

Capability	Definition
cdmi_data_redundancy	If present, this capability specifies the maximum number of redundancy copies that can be specified. If absent, redundancy copies specified will be ignored.
cdmi_infrastructure_redundancy	If present, this capability specifies the maximum number of infrastructure redundancy copies that can be specified. If absent, infrastructure redundancy copies specified will be ignored.
cdmi_data_dispersion	If present and “true”, the cloud storage system will disperse data. If absent, redundancy copies specified will be ignored.
cdmi_data_retention	If present and “true”, the cloud storage system shall support retention.
cdmi_data_autodelete	If present and “true”, the cloud storage system shall support the autodeletion of objects when retention ends.
cdmi_data_holds	If present and “true”, the cloud storage system shall support placing holds on objects.
cdmi_encryption	If present, this capability lists the encryption algorithms and key lengths supported. If absent, objects can not be encrypted.
cdmi_value_hash	If present, this capability lists the hash algorithm/lengths supported. If absent, objects can not be hashed. Values are in the form of “Algorithm Length”, for example, “SHA256”.
cdmi_max_latency	If present and “true”, the cloud storage system will tier data based on desired latency. If absent, the max latency specified will be ignored.
cdmi_max_throughput	If present and “true”, the cloud storage system will tier data based on desired throughput. If absent, the max throughput specified will be ignored.
cdmi_delete_method	If present, this capability lists the deletion methods supported. If absent, objects will not be securely deleted.
cdmi_RPO	If present and "true", the cloud storage system will manage data to achieve a specified RPO. If absent, the RPO specified will be ignored.
cdmi_RTO	If present and "true", the cloud storage system will manage data to achieve a specified RTO. If absent, the RTO specified will be ignored.

12.1.4 Data Object Capabilities

Table 16, “Capabilities for Data Objects” defines the capabilities for data objects in a cloud storage system.

Table 16 – Capabilities for Data Objects

Capability	Definition
cdmi_read_value	If present and “true”, the object’s value can be read.
cdmi_read_value_range	If present and “true”, the object’s value can be read with byte ranges.
cdmi_read_metadata	If present and “true”, the object’s metadata can be read.
cdmi_modify_value	If present and “true”, the object’s value can be modified.
cdmi_modify_value_range	If present and “true”, the object’s value can be modified with byte ranges.
cdmi_modify_metadata	If present and “true”, the object’s metadata can be modified.
cdmi_serialize_dataobject	If present and “true”, the object can be serialized.
cdmi_deserialize_dataobject	If present and “true”, the object can be deserialized.
cdmi_delete_dataobject	If present and “true”, the object can be deleted.

12.1.5 Container Capabilities

Table 17, “Capabilities for Containers” defines the capabilities for containers in a cloud storage system.

Table 17 – Capabilities for Containers

Capability	Definition
cdmi_list_children	If present and “true”, the container’s children can be listed.
cdmi_list_children_range	If present and “true”, the container’s children can be listed with ranges.
cdmi_read_metadata	If present and “true”, the container’s metadata can be read.
cdmi_modify_metadata	If present and “true”, the container’s metadata can be modified.
cdmi_snapshot	If present and “true”, the container allows a new snapshot to be created.
cdmi_serialize_container	If present and “true”, the container and all children’s contents can be serialized.
cdmi_create_dataobject	If present and “true”, the container allows a new object to be added.
cdmi_post_dataobject	If present and “true”, the container allows a new object to be added via POST.
cdmi_create_container	If present and “true”, the container allows a new container can be added.
cdmi_create_queue	If present and “true”, the container allows queues to be created.
cdmi_create_reference	If present and “true”, the container allows a new child reference can be added.
cdmi_delete_container	If present and “true”, the container can be deleted.
cdmi_move_container	If present and “true”, the container can be moved (via PUT) to another URI.
cdmi_copy_container	If present and “true”, the container can be copied (via PUT) to another URI.

12.1.6 Domain Capabilities

Table 18, “Capabilities for Domains” defines the capabilities for domains in a cloud storage system. (All capabilities refer to what can be done via CDMI operations.)

Table 18 – Capabilities for Domains

Capability	Definition
cdmi_create_domain	If present and "true", the domain allows a new subdomain to be added.
cdmi_delete_domain	If present and "true", the domain can be deleted.
cdmi_domain_summary	If present and "true", the domain supports domain summaries.
cdmi_domain_membership	If present and "true", the domain supports domain user management.
cdmi_list_children	If present and "true", the domain's children can be listed.
cdmi_read_metadata	If present and "true", the domain's metadata can be read.
cdmi_modify_metadata	If present and "true", the domain's metadata can be modified.
cdmi_create_container	If present and "true", the domain allows a new container can be added.
cdmi_create_queue	If present and "true", the domain allows queues to be created.
cdmi_copy_domain	If present and "true", the container can be copied (via PUT) to another URI.

12.1.7 Queue Object Capabilities

Table 19, “Capabilities of Queue Objects” defines the capabilities for queue objects in a cloud storage system.

Table 19 – Capabilities of Queue Objects

Capability	Definition
cdmi_read_value	If present and "true", the queue 's value can be read.
cdmi_read_metadata	If present and "true", the queue's metadata can be read.
cdmi_serialize_queue	If present and "true", the queue can be serialized.
cdmi_deserialize_queue	If present and "true", the queue can be deserialized.
cdmi_modify_value	If present and "true", the queue 's value and metadata can be modified.
cdmi_modify_metadata	If present and "true", the queue's metadata can be modified.
cdmi_delete_queue	If present and "true", the queue can be deleted.
cdmi_move_queue	If present and "true", the queue can be moved to another URI.
cdmi_copy_queue	If present and "true", the queue can be copied to another URI.
cdmi_reference_queue	If present and "true", the queue can be referenced from another queue.
cdmi_serialize_queue	If present and "true", the object can be serialized.

12.2 Read a Capabilities Object (CDMI Content Type)

Synopsis:

Reads from an existing capability object at the specified URI.

```
GET <root URI>/cdmi_capabilities/<Capability>/<TheCapability>
GET <root URI>/cdmi_capabilities/<Capability>/
   <TheCapability>?<fieldname>;<fieldname>
GET <root URI>/cdmi_capabilities/<Capability>/<TheCapability>?children:{range}
```

- <root URI> is the path to the CDMI cloud.
- <Capability> is zero or more intermediate capabilities containers.
- <TheCapabilitiy> is the name specified for the capabilities to be read from.
- <fieldname> is the name of a field from the response message body.
- <range> is a numeric range within the list of children.

The object can also be accessed at <root URI>/cdmi_objectid/<objectID>.

Capabilities:

The following capabilities describe the supported operations that can be performed when reading an existing capabilities object:

- All CDMI implementations must permit clients to read the metadata and contents of all capabilities objects.

Request Headers:

Header	Type	Value	Mandatory/Optional
Accept	Header String	"application/vnd.org.snia.cdmi.capabilities+json"	Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.object+json"	Mandatory
X-CDMI-Specification-Version	String Array	A comma separated list of versions supported by the client, for example, "1.0, 1.5, 2.0".	Mandatory

Request Message Body:

N/A

Response Headers:

Header	Type	Value	Mandatory/Optional
Content-Type	Header String	"application/vnd.org.snia.cdmi.capabilities+json"	Mandatory
X-CDMI-Specification-Version	Header String	The server shall respond with the highest version supported by both the client and the server, for example, "1.0".	Mandatory

Response Message Body:

Name	Type	Description	Mandatory/Optional
objectURI	JSON String	URI of the object as specified in the request.	Mandatory
objectID	JSON String	Object ID of the object	Mandatory
parentURI	JSON String	URI for the parent object	Mandatory
capabilites	JSON Object	A tag list of capabilities supported by the corresponding object. Capabilities in the "cdmi_capabilities" object are system-wide capabilities. Capabilities found in children objects correspond to the capabilities of a specific subset of objects.	Mandatory
childrenrange	JSON String	The range of the children returned in the children field.	Mandatory
children	JSON Array	Names of the children capabilities objects. For the root capabilities container, this includes "domain/", "container/", "dataobject/", and "queue/". Within each of these capabilities objects, further more specialized capabilities profiles can be specified by the cloud storage system.	Mandatory

If individual fields are specified in the GET request, only these fields are returned in the result body. Optional fields that are requested but do not exist are omitted from the result body. Requesting fields not defined in the standard result in a 400 Bad Request HTTP status code.

Response Status:

HTTP Status	Description
200 OK	Capabilities object list in response
400 Bad Request	Invalid parameter of field names in the request
401 Unauthenticated	Incorrect or missing authentication credentials
403 Unauthorized	Client lacks the proper authorization to perform this request

HTTP Status	Description
404 Not Found	A container was not found at the specified URI.
406 Not Acceptable	The server is unable to provide the object in the content-type specified in the Accept header.

Example Request:

GET to the root capabilities container URI to read all fields of the container

```
GET: /cdmi_capabilities HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.capabilities+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.capabilities+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/cdmi_capabilities/",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/",
    "capabilities" : {
        "cdmi_domains" : "true",
        "cdmi_export_nfs" : "true",
        "cdmi_export_webdav" : "true",
        "cdmi_export_iscsi" : "true",
        "cdmi_queues" : "true",
        "cdmi_notification" : "true",
        "cdmi_query" : "true",
        "cdmi_xmlrepresentation" : "true",
        "cdmi_metadata_maxsize" : "4096",
        "cdmi_metadata_maxitems" : "1024"
    },
    "childrenrange" : "0-3",
    "children" : [
        "domain/",
        "container/",
        "dataobject/",
        "queue/"
    ]
}
```

Example Request:

GET to the root capabilities container URI to read the capabilities and children of the container

```
GET: /cdmi_capabilities?capabilities;children HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.capabilities+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.capabilities+json
X-CDMI-Specification-Version: 1.0
{
    "capabilities" : {
        "cdmi_domains" : "true",
        "cdmi_export_nfs" : "true",
        "cdmi_export_webdav" : "true",
        "cdmi_export_iscsi" : "true",
        "cdmi_queues" : "true",
        "cdmi_notification" : "true",
        "cdmi_query" : "true",
        "cdmi_xmlrepresentation" : "true",
        "cdmi_metadata_maxsize" : "4096",
        "cdmi_metadata_maxitems" : "1024"
    },
    "children" : [
        "domain/",
        "container/",
        "dataobject/",
        "queue/"
    ]
}
```

Example Request:

GET to the root capabilities container URI to read the first two children of the container

```
GET: /cdmi_capabilities?childrenrange;children:0-1 HTTP/1.1
Host: cloud.example.com
Accept: application/vnd.org.snia.cdmi.capabilities+json
Content-Type: application/vnd.org.snia.cdmi.object+json
X-CDMI-Specification-Version: 1.0
```

The response looks like:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.capabilities+json
X-CDMI-Specification-Version: 1.0
{
    "childrenrange" : "0-1",
    "children" : [
        "domain/",
        "container/"
    ]
}
```

13 Exported Protocols

CDMI containers are accessible not only via CDMI as a data path, but also via other protocols as well. This access is especially useful for using CDMI as the storage interface for a cloud-computing environment, as Figure 9 shows.

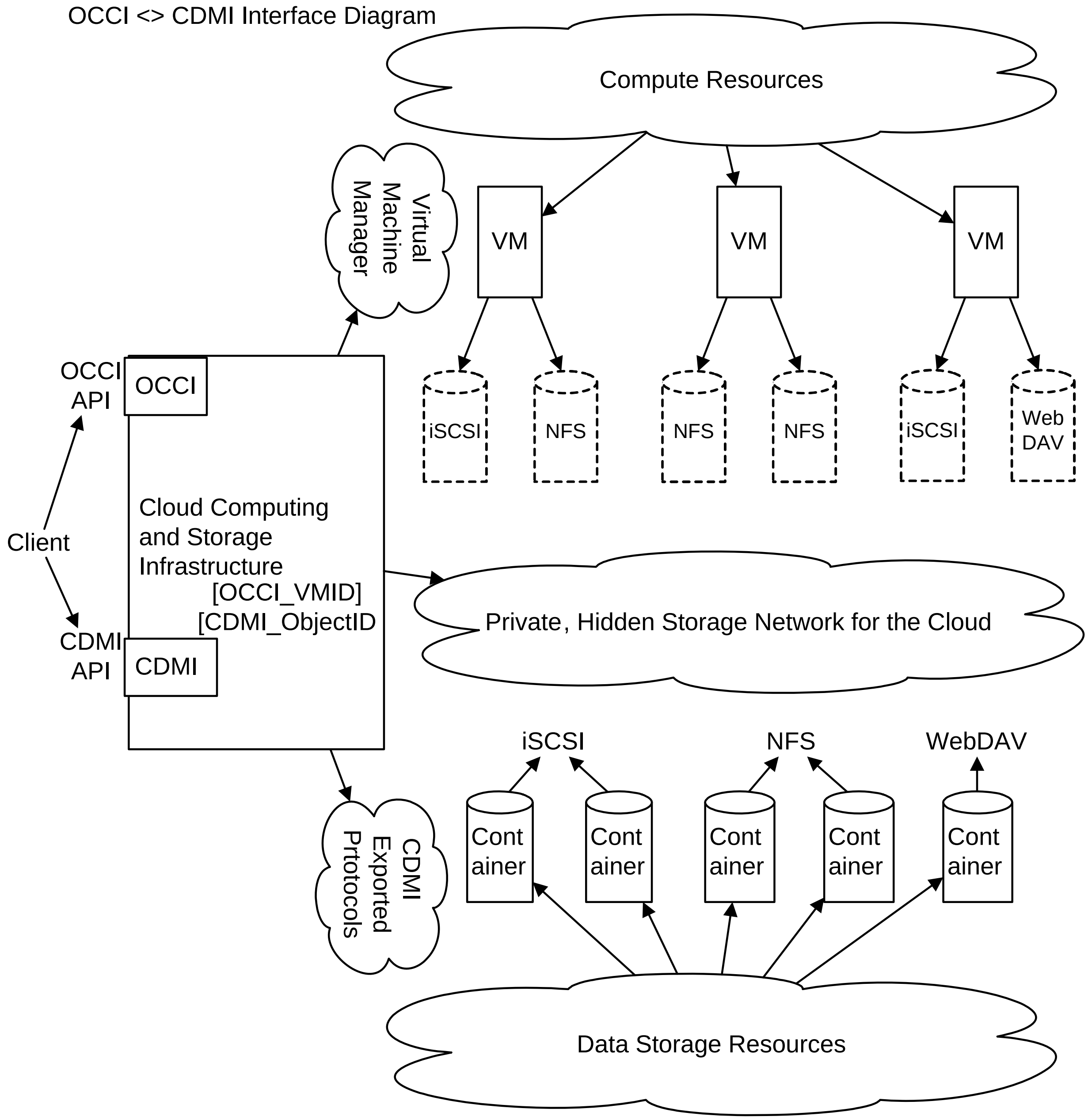


Figure 9 – CDMI and OCCI in an Integrated Cloud Computing Environment

The exported protocols from CDMI containers can be used by the virtual machines in the cloud-computing environment as virtual disks on each guest as shown. The cloud computing infrastructure management is shown as implementing both OCCI and CDMI interfaces. With the internal knowledge of the network and the virtual machine manager's mapping of drives, this infrastructure can hook the CDMI containers to the guests using the appropriate exported protocol.

To do this interoperably, CDMI provides a type of exported protocol that contains information obtained via the OCCI interface. In addition, OCCI provides a type of storage that corresponds to a CDMI container that is exported with a specific type of protocol used by OCCI. A client of both interfaces would perform the following operations as an example:

1. The client creates a CDMI container through the CDMI interface and exports it as an OCCI export protocol type. The CDMI container objectID is returned as a result.
2. The client then creates a virtual machine through the OCCI interface and attaches a storage volume of type CDMI using the objectID and protocol type. The OCCI virtual machine ID is returned as a result.
3. The client then updates the export protocol structure of the CDMI container object with the OCCI virtual machine ID to allow the virtual machine access to the container.
4. The client then starts the virtual machine through the OCCI interface.

13.1 Exported Protocol Structure

The export of a container, via data path protocols other than CDMI, is done by creating or updating a container and supplying one or more export protocol structures, one for each such protocol.

The elements of the export protocol structure include:

- The protocol being used
- The identify of the container as standardized by the protocol
- The list of who can access that container via that protocol, identified as standardized by that protocol (may leverage the CDMI domains for this)

CDMI standardizes several export protocol structures for various protocols. Export protocol structures can also be defined for proprietary and vendor extensions of protocols.

13.2 OCCI Exported Protocol

CDMI defines an export protocol structure for the OGF standard: Open Cloud Computing Interface (OCCI) as follows:

- Protocol is "OCCI/<protocol standard>" (i.e., OCCI/NFSv4)
- The identifier is the CDMI objectid
- The list of who can access is a list of OCCI VM IDs

An example of an OCCI export protocol structure in JSON is as follows:

```
"OCCI/iSCSI" : {"identifier" :
    "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==", "permissions" :
    "f63aaa26-30b7-4a30-91ca-1d03c1e52214" }
```

13.3 iSCSI Exported Protocol

CDMI defines an export protocol structure for the iSCSI standard as follows:

- Protocol is "Network/iSCSI"
- Fully qualified IQN plus Logical Unit Name (LUN) (See SPC standard)
- List of hosts/IP addresses with access (or CHAP users)

Note: This section is incomplete and needs further definition.

13.4 NFS Exported Protocol

CDMI defines an export protocol structure for the NFS standard as follows:

- Protocol is "Network/NFSv4"
- The path of the share as presented to clients (including server host name)
- The list of who can access the share

This example shows an NFSv4 export protocol structure in JSON:

```
"Network/NFSv4" : { "identifier" : "/users", "permissions" : "domain" }
```

In this example, the value "domain" in the permissions field indicates that user credentials should be mapped through the domain membership in the domain of the CDMI container being exported.

Note: This section is incomplete and needs further definition.

13.5 FCOE Exported Protocol

CDMI defines an export protocol structure for the FCoE standard as follows:

- Protocol is "Network/FCoE"
- World Wide Port Name (WWPN) and Logical unit name

Note: This section is incomplete and needs further definition.

14 Snapshots

A snapshot is a point-in-time image of a container and its contents. The client names a snapshot of a container at the time the snapshot is taken. The operation results in a child destination container of the **cmdi_snapshots** container under the source container. The snapshot does not include the cdmi_snapshots child container or its contents (see Figure 10, “Snapshot Operation”).

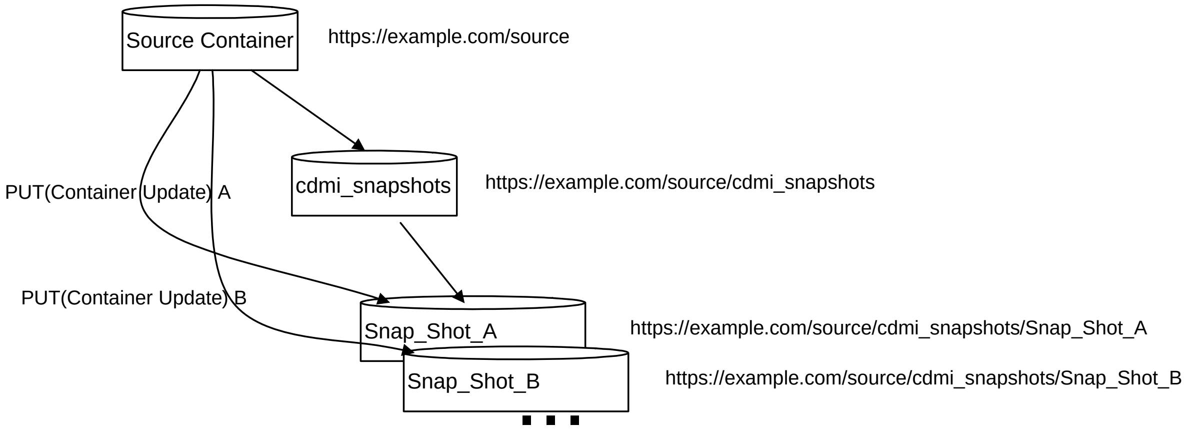

Source Container
https://example.com/source
cdmi_snapshots
https://example.com/source/cdmi_snapshots
PUT(Container Update) A
PUT(Container Update) B
Snap_Shot_A
https://example.com/source/cdmi_snapshots/Snap_Shot_A
Snap_Shot_B
https://example.com/source/cdmi_snapshots/Snap_Shot_B
. . .

Figure 10 – Snapshot Operation

To take a snapshot, a Container Update operation is performed, as described in Section 9.6, “Update a Container (CDMI Content Type)”, supplying the *snapshot* parameter (the name of the snapshot).

Table 20 describes the snapshot parameter of a container update operation.

Table 20 – Snapshot Parameter of the Container Update Operation

Name	Type	Description
snapshot	JSON String	Name of the snapshot to be taken. If a snapshot is added or changed, the PUT operation only returns after the snapshot is added to the snapshot list. Once created, snapshots can be accessed as children containers under the cdmi_snapshots child container of the container receiving a snapshot.

Snapshots can be accessed in place or used as the source for copy operations, restoring a container to a previous point in time.

15 Serialization/Deserialization

Cloud storage provides benefits to users and applications due to the pervasive presence and "always on" availability. Occasionally, data must be moved between, into, or out of clouds in bulk operations. Cloud serialization operations are enabled by normalizing data to a canonical, self-describing format. Use case examples of cloud serialization include, but are not limited to:

- Data migration between clouds
- Data migration during upgrades (or replacements) of cloud implementations
- Robust backup

The canonical format of serialized data describes how the data is to be represented in a byte stream. This stream may be transported in any desirable conveyance, and as long as no alteration occurs, the data may be reconstituted on the destination system.

15.1 Exporting Serialized Data

A canonical encoding of the data is obtained by creating a new data object and specifying that the source for the creation is to serialize a given CDMI data object, container, or queue. On a successful serialization, the result will be a data object that is created with the serialized data as its value. If a container has an exported block protocol, the serialized data may contain the block-by-block contents of that container along with its metadata as if it were a data object.

The resulting data object that is produced is the canonical representation of the selected data object, container, and children or queue.

- If the source specified is a data object, the canonical format will contain the data object contents and its metadata.
- If the source being specified is a queue, the queue contents and its metadata will be included.
- If the source being specified is a container, all children containers, data objects, and queues of the specified container will be included.

Only objects that the user who is performing the serialization operation has permissions to read will be included in the resulting serialized object.

15.2 Importing Serialized Data

Canonical data may be de-serialized back into the cloud by creating a new data object, container, or queue and by specifying that the source for the creation is to deserialize a given CDMI data object.

The destination may or may not exist previously. If not, a "create" operation is performed. If a container already exists, an "update" operation with serialized data is not permitted. Data objects are recreated as specified in the canonical format, including all metadata and the data object identifiers. If the serialized data object contains block-by-block data from a container that was exporting a block protocol, the container will be created with that data as its new value, but the exported block protocol will need to be set up with a separate update.

If the user who is deserializing a serialized data object has the "cross-domain" privilege and has not specified a domainURI as part of the deserialize operation, the original domainURIs from the serialized object will be used. If any of the specified domainURIs are not valid in the context of the storage system on which the deserialization operation is being performed, the entire deserialize operation will fail.

If the user who is deserializing a serialized object specifies a domainURI as part of the deserialize operation, the domainURI of every object being deserialized will be set to the specified domainURI. If the user does not have the "cross_domain" privilege, only the domainURI of the parent object can be specified.

If the user who is deserializing a serialized object does not specify a domainURI and does not have the "cross_domain" privilege, then the deserialization operation will only be successful if all objects have the same domainURI as the parent object on which the deserialization operation is being performed.

15.2.1 Canonical Format

The canonical format shall represent specified data objects and containers, as they exist within the storage system. Each object shall be represented by the metadata for the object, identifiers, and the data stream contents of the data object. Because metadata is inherited from enclosing containers, all parent metadata shall be represented in the canonical format (essentially flattening the hierarchy). To preserve the actual metadata values that apply to the data object that is being serialized, the non-overridden metadata is included from both the immediate parent container of the specified object and from the parent of each higher-level container.

The canonical format must have the following characteristics:

- YAML schema or recursive JSON for the data object, consistent with the rest of CDMI
- User and data system metadata for each data object/container
- Data stream contents for each data object and queue
- Binary data is represented using the stream notation in YAML or JSON escaped
- Typing of data elements is consistent with YAML or JSON

15.2.2 Example YAML Canonical Serialized Format

In this example, a data object has been selected for serialization. All the parent metadata has been captured in a parentmetadata object.

```
%YAML 1.2
---
rootobject: 1234567890
---
parentmetadata: &id001
   example: "testing"
   test: 42
---
container: &id002 *id001
   id: !!application/vnd.snia.cdmi.id 1234567890
  children: [99999]
---
dataobject: *id002
   id: !!application/vnd.snia.xdmi.id 99999
  abool.prop: !!bool true
  test: 43
  datastream_type: image/jpeg
  datastream: !!binary |
      R0lGODlhDAAMAIQAAP//9/X
      17unp5WZmZgAAAOfn515eXv
       Pz7Y6OjuDg4J+fn5OTk6enp
       56enmleECcgggoBADs=mZmE
```

15.2.3 Example JSON Canonical Serialized Format

In this example, a data object and a queue in a container have been selected for serialization.

```
{
    "objectURI" : "/MyContainer",
    "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
    "parentURI" : "/",
    "domainURI" : "/cdmi_domains/MyDomain",
    "capabilitiesURI" : "/cdmi_capabilities/Container",
    "completionStatus" : "Complete",
    "metadata" : {

    },
    "exports" : {
        "OCCI/iSCSI" : {
            "identifier" :
   "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
            "permissions" : "f63aaa26-30b7-4a30-91ca-1d03c1e52214"
        },
        "Network/NFSv4" : {
            "identifier" : "/users",
            "permissions" : "domain"
        }
    },
    "childrenrange" : "0-1",
    "children" : [
        {
            "objectURI" : "/MyContainer/MyDataObject.txt",
           "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
            "parentURI" : "/MyContainer/",
            "domainURI" : "/cdmi_domains/MyDomain",
            "capabilitiesURI" : "/cdmi_capabilities/DataObject",
            "completionStatus" : "Complete",
            "mimetype" : "text/plain",
            "metadata" : {

            },
            "valuerange" : "0-37",
            "value" : "This is the Value of this Data Object"
        },
        {
            "objectURI" : "/MyContainer/MyQueue",
           "objectID" : "AAAAFAAo7EFMb3JlbSBpcHN1bSBkb2xvciBzaXQgYW1ldCBhbWV0Lg==",
            "parentURI" : "/MyContainer/",
            "domainURI" : "/cdmi_domains/MyDomain/",
            "capabilitiesURI" : "/cdmi_capabilities/Queue",
            "completionStatus" : "Complete",
            "metadata" : {

            },
            "queueValues" : "2",
            "valuerange" : [
                "0-2",
                "0-4"
            ],
            "value" : [
                "red",
                "blue"
            ]
        }
    ]
}
```

To allow efficient deserialization in stream mode when serializing containers to JSON, the children array should be the last item in the container JSON object.

16 Metadata

16.1 Access Control

Access control comprises the mechanisms by which various types of access to objects and containers are authorized and permitted or denied. CDMI uses the well-known mechanism of *access control lists* (ACLs). ACLs are lists of permissions-granting or permissions-denying entries called *access control entries* (ACEs).

16.1.1 ACL and ACE Structure

An ACL is an ordered list of ACEs. The two types of ACEs in CDMI are ALLOW and DENY. An ALLOW ACE grants some form of access to a *principal*. Principals are either users or groups, and are represented by *identifiers*. A DENY ACE denies access of some kind to a principal. For instance, a DENY ACE could deny the ability to write the metadata or ACL of an object, but could remain silent on other forms of access. In that case, if another ACE ALLOWs write access to the object, the principal is allowed to write the object's data, but nothing else.

ACEs are composed of five fields. In C, their declaration would look like this

```
/*
 * ACE structure
 */
typedef unsigned int   uint_t;
typedef char           utf8_t;
typedef char*          utf8str_t;

struct cdmi_ace_t {
       uint_t       type;
       utf8str_t    who;
       uint_t       flags;
       uint_t       access_mask;
       uint_t       timestamp;   // Unix timestamp (seconds)
};
```

While the type, flags, and access_mask are specified as unsigned integers, for efficiency, each defined bit in them has a corresponding string (in C, the label-pasted form of the macro), which can be used where desired for readability. Similarly, the date shall be represented as a string in ISO-8601 point-in-time representation, or as an integer (UNIX timestamp format). Implementations shall be able to convert between these formats as necessary. The preferred representation for storage is the integer format, while the preferred representation for display is via strings.

16.1.2 ACE Type

The following ACE types are defined, following NFSv4:

```
/*
 * ACE types
 *
 *      macro/constant form    bitwise form    string form
 */
const CDMI_ACE_ACCESS_ALLOW   = 0x00000000;    "ALLOW"
const CDMI_ACE_ACCESS_DENY    = 0x00000001;    "DENY"
const CDMI_ACE_SYSTEM_AUDIT   = 0x00000002;    "AUDIT"
```

Note: The reason that the string forms may be safely abbreviated is that they are local to the ACE structure type, as opposed to constants, which are relatively global in scope.

ACLs are customarily ordered with the DENY ACEs at the front of the list, but there are no known server implementations which enforce this. The reason for the custom is that an ACL like this

```
ALLOW          EVERYONE@      NONE       ALL_PERMS     200912250001

DENY           JIM            NONE       ALL_PERMS     200912250002
```

would not have the desired effect of allowing access to everyone except Jim, as ACLs are evaluated in order, and JIM, being a member of EVERYONE@, would be granted access before the DENY ACE was ever encountered.

However, the client is responsible for ordering the ACEs in an ACL. This ordering conforms to both Windows and NFSv4. The server shall not enforce any ordering, and shall store and evaluate the ACEs in the order given by the client.

16.1.3 ACE Who

The special "who" identifiers need to be understood universally, rather than in the context of a particular DNS domain (see Table 21, “Who Identifiers”). Some of these identifiers cannot be understood when an NFS client accesses the server, but have meaning when a local process accesses the file. The ability to display and modify these permissions is permitted over NFS, even if none of the access methods on the server understands the identifiers.

Table 21 – Who Identifiers

Who	Description
"OWNER@"	The owner of the file
"GROUP@"	The group associated with the file
"EVERYONE@"	The world
"ANONYMOUS@"	Accessed without any authentication
"AUTHENTICATED@"	Any authenticated user (opposite of ANONYMOUS)
"ADMINISTRATOR@"	A user with administrative status, e.g., root
"ADMINUSERS@"	A group whose members are given administrative status

To avoid name conflicts, these special identifiers are distinguished by an appended `"@"` (with no domain name).

16.1.4 ACE Flags

CDMI allows for nested containers and mandates that objects and subcontainers be able to inherit access permissions from their parent containers. However, it is not enough to simply inherit all permissions from the parent; it might be desirable, for example, to have different default permissions on child objects and subcontainers of a given container. The following flags govern this behavior.

```
/*
 * ACE flag bits
 *
 *      macro/constant form                  bitwise form    string form
 */
const CDMI_ACE_FLAGS_NONE                   = 0x00000000;   "NO_FLAGS"
const CDMI_ACE_FLAGS_OBJECT_INHERIT_ACE     = 0x00000001;   "OBJECT_INHERIT"
const CDMI_ACE_FLAGS_CONTAINER_INHERIT_ACE  = 0x00000002;   "CONTAINER_INHERIT"
const CDMI_ACE_FLAGS_NO_PROPAGATE_ACE       = 0x00000004;   "NO_PROPAGATE"
const CDMI_ACE_FLAGS_INHERIT_ONLY_ACE       = 0x00000008;   "INHERIT_ONLY"
const CDMI_ACE_FLAGS_INHERITED_ACE          = 0x00000100;  (see Section ACL
   Timestamp)
```

- An ACE on which CDMI_ACE_FLAGS_OBJECT_INHERIT_ACE is set is inherited by objects in a container, but not subcontainers. This effectively causes the inheritance to be one level deep.
- An ACE on which CDMI_ACE_FLAGS_CONTAINER_INHERIT_ACE is set is inherited by subcontainers of a container, but not the objects. This ACE applies only to containers, in other words.
- An ACE on which CDMI_ACE_FLAGS_NO_PROPAGATE_ACE is not inherited by any objects or subcontainers. It applies only to the object or container on which it is set.
- An ACE on which CDMI_ACE_FLAGS_INHERIT_ONLY_ACE is set is only applicable when evaluating access to child objects or subcontainers. It is ignored when evaluating access for the object or container on which it is set. This flag is particularly useful for top-level containers, which may specify any kind of default permissions for child objects, but themselves may only be writable by their owners or administrators, for instance.

16.1.5 ACE Mask Bits

The *mask* field of an ACE contains 32 bits. The following are defined in CDMI; their values are taken from the IETF NFSv4 RFC 3530.

```
/*
 * ACE access_mask bits
 *
 *      macro/constant form          bitwise form    string form
 */
const CDMI_ACE_READ_OBJECT          = 0x00000001;    "READ_OBJECT"
const CDMI_ACE_LIST_CONTAINER       = 0x00000001;    "LIST_CONTAINER"
const CDMI_ACE_WRITE_OBJECT         = 0x00000002;    "WRITE_OBJECT"
const CDMI_ACE_ADD_OBJECT           = 0x00000002;    "ADD_OBJECT"
const CDMI_ACE_APPEND_DATA          = 0x00000004;    "APPEND_DATA"
const CDMI_ACE_ADD_SUBCONTAINER     = 0x00000004;    "ADD_SUBCONTAINER"
const CDMI_ACE_READ_METADATA        = 0x00000008;    "READ_METADATA"
const CDMI_ACE_WRITE_METADATA       = 0x00000010;    "WRITE_METADATA"
const CDMI_ACE_EXECUTE              = 0x00000020;    "EXECUTE"
const CDMI_ACE_DELETE_OBJECT        = 0x00000040;    "DELETE_OBJECT"
const CDMI_ACE_DELETE_SUBCONTAINER  = 0x00000040;    "DELETE_SUBCONTAINER"
const CDMI_ACE_READ_ATTRIBUTES      = 0x00000080;    "READ_ATTRIBUTES"
const CDMI_ACE_WRITE_ATTRIBUTES     = 0x00000100;    "WRITE_ATTRIBUTES"
const CDMI_ACE_DELETE                   = 0x00010000;    "DELETE"
const CDMI_ACE_READ_ACL                 = 0x00020000;    "READ_ACL"
const CDMI_ACE_WRITE_ACL                = 0x00040000;    "WRITE_ACL"
const CDMI_ACE_WRITE_OWNER              = 0x00080000;    "WRITE_OWNER"
const CDMI_ACE_SYNCHRONIZE              = 0x00100000;    "SYNCHRONIZE"
const CDMI_ACE_SET_RETENTION            = 0x10000000;    "SET_RETENTION"
```

Several summary values are useful for routine work:

```
const CDMI_ACE_READ                     = 0x00000009;    "READ"
const CDMI_ACE_READ_ALL                 = 0x00020089;    "READ_ALL"
const CDMI_ACE_WRITE                    = 0x00000016;    "WRITE"
const CDMI_ACE_WRITE_ALL                = 0x00040156;    "WRITE_ALL"
const CDMI_ACE_RW                       = 0x0000001F;    "RW"
const CDMI_ACE_RW_ALL                   = 0x0006006F;    "RW_ALL"
const CDMI_ACE_ALL                      = 0x1007FFFF;    "ALL_PERMS"
```

Note that CDMI_ACE_WRITE_OWNER is not included in CDMI_ACE_WRITE_ALL or CDMI_ACE_ALL. This permission—to change the owner of an object—is generally only given to admins and the object's owner.

Note that several constants are duplicated in the above list. This duplication is because several of the flags apply to both objects and containers:

Object type	constant	string form
object	0x01	"READ_OBJECT"
container	0x01	"LIST_CONTAINER"
object	0x02	"WRITE_OBJECT"
container	0x02	"ADD_OBJECT"
object	0x04	"APPEND_DATA"
container	0x04	"ADD_SUBCONTAINER"
object	0x40	"DELETE_OBJECT"
container	0x40	"DELETE_SUBCONTAINER"

Implementations should use the correct string form for display of permissions, if the object type is known. If the object type is unknown, the "object" version of the string should be used.

16.1.6 ACL Timestamp

The CDMI model of permissions inheritance requires that all object access be governed by a *logical ACL*. This ACL is constructed by walking the parentage chain for an object back to the root container, appending all inheritable ACEs to the ACL actually on the object as the upward traversal is done. This operation is obviously expensive; good caching on the part of server implementations will be required to support nesting to any significant degree. To support said caching, CDMI provides the following flag.

```
const CDMI_ACE_FLAGS_INHERITED_ACE   = 0x00000100;   "INHERITED_ACE"
```

This flag should be set for all inherited ACEs that are appended to an object's original ACL. A server may use this flag as follows:

- By design, it should be easy and cheap to list an object's ancestors (parent, parent's parent, and so on).

- A time-stamped list of parent objects, whose ACLs have been changed, should be kept.
- Comparing an object's parents against the list of changed parents, whose timestamps are newer than the object's ACL timestamp, should provide an inexpensive way of determining whether a given object's ACL is current.
- When an object's timestamp is older than any one of its parents, the ACL should be reevaluated and its timestamp set to the current time. Note that race conditions here are ignored: it is not usual that many ACL-setting operations are in place at once, except upon setting of ACLs in an entire tree of objects, and in that case, each object is generally only touched once.

16.1.7 ACL Evaluation Utilities

Before describing the evaluation algorithm for permitting access to an object, defining a couple of utility routines will help to simplify the control flow. In the following example, equality is used loosely: flags can be either numbers or strings, for instance, and the proper conversion is assumed. Other substantial entities are treated similarly.

```
//
// figure out whether an ace anywhere up the inheritance chain applies
// to the acl on a given object
//
def logically_applies (object o, ace a, bool recursing)
   if (a.flags == CDMI_ACE_FLAGS_NONE)
                 return 1
   else if (!recursing)
          if (a.flags | CDMI_ACE_FLAGS_INHERIT_ONLY_ACE != 0)
                 return 0
   else
          if (CDMI_ACE_FLAGS_NO_PROPAGATE_ACE != 0)
                 return 0
   else if (o.type == object &&
                 a.flags | CDMI_ACE_FLAGS_OBJECT_INHERIT_ACE != 0)
                       return 1
          else if (o.type == container &&
                 a.flags | CDMI_ACE_FLAGS_CONTAINER_INHERIT_ACE != 0)
                       return 1
   else
          return 0
enddef
//
// make an ACE which legally apply to a REF
//
def ref_ace (ACE ace)
   ACE    r = ace;
   r.access_mask = r.access_mask XOR "READ_OBJECT"
   return r;
enddef
//
```

```
// get the logical ACL for object o
//
def get_logical_acl (object o)
    acl A = NULL
    bool recursing = false

    do
            if (o != NULL)
                    foreach ace a in o.acl
                            if logically_applies(o, a, recursing)
                                    if (o.type == REF)
                                            A += ref_ace(a)
                                    else
                                            A += a        // append ace a to acl A
                    o = parent(o)
                    recursing = true
            else
                    break
    A.timestamp = now()
    return A
enddef
```

16.1.8 ACL Evaluation

When evaluating whether access to a particular object *O* by a principal *P* shall be granted, the server traverses the object's logical ACL (its ACL after processing inheritance from ancestor containers) in list order, using a temporary permissions bitmask *m*, initially empty (all zeroes).

- If the ACL timestamp is nonexistent or is older than that of some parent (see foregoing discussion in previous section), use get_acl(O, P) to set the physical ACL equal to the logical ACL.
- If the object still does not contain an ACL, the algorithm terminates and access is denied for all users and groups. This condition is not expected, as CDMI implementations should require an inheritable default ACL on all root containers.
- ACEs that do not refer to the principal *P* requesting the operation are ignored.
- If an ACE is encountered that denies access to *P* for any of the requested mask bits, access is denied and the algorithm terminates.
- If an ACE is encountered that allows access to *P*, the permissions mask *m* for the operation is XORed with the permissions mask from the ACE. If *m* is sufficient for the operation, access is granted and the algorithm terminates.
- If the end of the ACL list is reached and permission has neither been granted nor explicitly denied, access is denied and the algorithm terminates, unless the object is a container root. In this case, the server shall:
  - — Allow access to the container owner, ADMINISTRATOR@, and any member of ADMINUSERS@
  - — Log an event indicating what has happened

  Note: When permission for the desired access is not explicitly given, even ADMINISTRATOR@ and equivalents are denied for objects that aren't container roots. When an admin needs to access an object in such an instance, the root container object must be accessed and its inheritable ACEs changed in a way as to allow access to the original object. The resulting log entry then provides an audit trail for the access.

When a root container is created and no ACL is supplied, the server shall place an ACL containing the following ACEs on the container:

```
{
    [
        {
            "ALLOW",
            "OWNER@",
            "NO_FLAGS",
            "ALL_PERMS",
            now()
        } ,
        {
            "ALLOW",
            "AUTHENICATED@",
            "NO_FLAGS",
            "READ",
            now()
        }
    ]
}
```

As ACLs are metadata, they are PUT and GOTTEN through the metadata field of a PUT or GET request. The syntax is as follows:

```
ACL = { ACE [, ACE ...] }
ACE = { acetype , identifier , aceflags , acemask , acetime }
acetype = uint_t | acetypeitem
identifier = utf8string_t
aceflags = uint_t | aceflagsstring
acemask = uint_t | acemaskstring
acetime = uint_t | datetimestring // Unix seconds or datetime

acetypeitem = aceallowedtype |
              acedeniedtype |
              aceaudittype
aceallowedtype = "CDMI_ACE_ACCESS_ALLOWED_TYPE" | 0x0
acedeniedtype  = "CDMI_ACE_ACCESS_DENIED_TYPE" | 0x01
aceaudittype   = "CDMI_ACE_SYSTEM_AUDIT_TYPE" | 0x02

aceflagsstring = aceflagsitem [| aceflagsitem ...]
aceflagsitem = aceobinherititem |
               acecontinherititem |
               acenopropagateitem |
               aceinheritonlyitem
aceobinherititem   = "CDMI_ACE_OBJECT_INHERIT_ACE" | 0x01
acecontinherititem = "CDMI_ACE_CONTAINER_INHERIT_ACE" | 0x02
acenopropagateitem = "CDMI_ACE_NO_PROPAGATE_INHERIT_ACE" | 0x04
aceinheritonlyitem = "CDMI_ACE_INHERIT_ONLY_ACE" | 0x08

acemaskstring = acemaskitem [| acemaskitem ...]
acemaskitem = acereaditem | acewriteitem |
              aceappenditem | acereadmetaitem |
              acewritemetaitem | acedeleteitem |
              acedelselfitem | acereadaclitem |
              acewriteaclitem | acewriteowneritem
```

```
acereaditem = "CDMI_ACE_READ_OBJECT" |
              "CDMI_ACE_LIST_CONTAINER" |      0x01
acewriteitem = "CDMI_ACE_WRITE_OBJECT" |
               "CDMI_ACE_ADD_OBJECT" |         0x02
aceappenditem = "CDMI_ACE_APPEND_DATA" |
                "CDMI_ACE_ADD_SUBCONTAINER" |  0x04
acereadmetaitem = "CDMI_ACE_READ_METADATA" |   0x08
acewritemetaitem = "CDMI_ACE_WRITE_METADATA" | 0x10
acedeleteitem = "CDMI_ACE_DELETE_OBJECT" |
                "CDMI_ACE_DELETE_SUBCONTAINER" | 0x40
acedelselfitem = "CDMI_ACE_DELETE" |          0x10000
acereadaclitem = "CDMI_ACE_READ_ACL" |        0x20000
acewriteaclitem = "CDMI_ACE_WRITE_ACL" |      0x40000
acewriteowneritem = "CDMI_ACE_WRITE_OWNER" |  0x80000
```

When ACE masks are presented in numeric format, they shall, at all times, be specified in hexadecimal notation with a leading "0x". This format allows both servers and clients to quickly determine which of the two forms of a given constant is being used. When masks are presented in string format, they shall be converted to numeric format and then evaluated using standard bitwise operators.

16.1.9 Example ACE Mask Expressions

```
"READ_ALL" | 0x02
```

```
   evaluates to 0x09 | 0x02 == 0x0B
```

```
0xFFFFF
```

```
   evaluates to 0x000FFFFF == CDMI_ACE_ALL
```

```
"RW_ALL" | DELETE
```

```
   evaluates to 0x0060006F | 0x00100000 == 0x0070006F
```

16.1.10 Canonical Format for ACE Hexadecimal Quantities

ACE mask expressions shall always be evaluated and converted to a single hexadecimal value before transmission in an HTTP protocol datagram. Applications or utilities that display them to users should convert them into a text expression prior to display and accept user input in text format as well. The C bitwise operators "|" and "&" should be used for textual representations of bitmask entities.

The following technique should be used to decompose masks into strings. A table of masks and string equivalents should be maintained and ordered from greatest to least:

```
0x1007FFFF    "ALL_PERMS""ALL_PERMS"
   0x0006006F    "RW_ALL""RW_ALL"
   0x0000001F    "RW""RW"
        ...
   0x00000002    "WRITE_OBJECT""ADD_OBJECT"
   0x00000001    "READ_OBJECT""LIST_CONTAINER"
```

Given an access mask M, the following is repeated until M == 0:

1 Select the highest mask *m* from the table such that M & *m* == *m*

2 If the object is a container, select the string from the 3rd column; otherwise select the string from the 2nd column.

3 Bitwise subtract *m* from M, i.e. set M = M xor *m*

The complete textual representation is then all the selected strings concatenated with " | " between them, e.g. "ALL_PERMS | WRITE_OWNER". The strings should appear in the order they are selected.

A similar technique should be used for all other sets of hex/string equivalents.

Note that this algorithm, properly coded, requires only one (often partial) pass through the corresponding string equivalents table.

16.1.11 JSON Format for ACLs

ACE flags and masks are members of a 32-bit quantity that is widely understood in its hexadecimal representations. The JSON data format does not support hexadecimal integers, however. For this reason, all hexadecimal integers in CDMI ACLs shall be represented as quoted strings containing a leading "0x".

ACLs containing a single ACE shall be represented in JSON as follows:

```
{
    "ACL" : {
        "acetype" : "0xnn",
        "identifier" : "<user-or-group-name>",
        "aceflags" : "0xnn",
        "acemask" : "0xnn",
        "acetime" : 12345678
    }
}
```

ACLs containing multiple ACEs shall be represented in JSON as follows:

```
{
    "ACL" : [
        {
            "acetype" : "0xnn",
            "identifier" : "<user-or-group-name>",
            "aceflags" : "0xnn",
            "acemask" : "0xnn",
            "acetime" : 12345678
        },
        {
            "acetype" : "0xnn",
            "identifier" : "<user-or-group-name>",
            "aceflags" : "0xnn",
            "acemask" : "0xnn",
            "acetime" : 12345678
        }
    ]
}
```

ACEs in such an ACL shall be evaluated in order as they appear. An example of an ACL embedded in a response to a GET request is as follows:

```
HTTP/1.1 200 OK
Content-Type: application/vnd.org.snia.cdmi.dataobject+json
X-CDMI-Specification-Version: 1.0
{
    "objectURI" : "/MyContainer/MyDataObject.txt",
    "objectID" : "AABwbQAQb/ENV52Ai8a3MA==",
    "parentURI" : "/MyContainer/",
    "domainURI" : "/cdmi_domains/MyDomain/",
    "capabilitiesURI" : "/cdmi_capabilities/DataObject/",
    "percentComplete" : "Complete",
    "mimetype" : "text/plain",
    "metadata" : {
        "cdmi_size" : "17",
        "ACL" : {
            "acetype" : "0x00",
            "identifier" : "EVERYONE@",
            "aceflags" : "0x00",
            "acemask" : "0x00020089",
            "acetime" : 12345678
        }
    },
    "valuerange" : "0-17",
    "value" : "Hello CDMI World!"
}
```

16.2 Support for User Metadata

All objects that support metadata must permit the inclusion of arbitrary user-defined metadata items, with the restriction that the name of a user-defined metadata item shall not start with the prefix "cdmi_".

- The maximum number of user-defined metadata items is specified by the capability "cdmi_metadata_maxitems".
- The maximum size of each user-defined metadata item is specified by the capability "cdmi_metadata_maxsize".

16.3 Support for Storage System Metadata

Once an object has been created, the storage system metadata, as described in Table 22, “Storage System Metadata”, shall be generated by the cloud storage system and shall immediately be made available to a CDMI client in the metadata that is returned as a result of the create operation and any subsequent retrievals.

Table 22 – Storage System Metadata

Metadata Name	Description	Source	Permissions
cdmi_size	The number of bytes stored in the data object.	Server	Read-Only
cdmi_ctime	The time when the data object was created, in ISO-8601 point-in-time format.	Server	Read-Only

Table 22 – Storage System Metadata

Metadata Name	Description	Source	Permissions
cdmi_atime	The time when the data object was last accessed in ISO-8601 point-in-time format. The access or modification of a child is not considered an access of a parent container (access/modify times do not propagate up the tree).	Server	Read-Only
cdmi_mtime	The time when the data object was last modified, in ISO-8601 point-in-time format. The modification of a child is not considered a modification of a container (modification times do not propagate up the tree)	Server	Read-Only
cdmi_acount	The number of times that the object has been accessed since it was originally created. Accesses include all reads, writes, and lists.	Server	Read-Only
cdmi_mcount	The number of times that the object has been modified since it was originally created. Modifications include all value and metadata changes. Modifications to metadata resulting from reads (such as updates to atime) do not count as a modification.	Server	Read-Only
cdmi_hash	The hash of the value of the object, encoded as a base64 string. This metadata field shall be present when the "cdmi_value_hash" data system metadata for the object or a parent object indicates that the value of the object should be hashed.	Server	Read-Only
cdmi_acl	Standard ACL metadata. (Based on NFSv4?) If not specified when the object is created, this metadata will be filled in by the system.	Client	Read/Write

16.4 Support for Data System Metadata

When specified, data system metadata provides guidelines to the cloud storage system on how to provide storage data services for data managed through the CDMI interface.

As described in Table 23, data system metadata is inherited from parent objects to any children. If a child explicitly contains data system metadata, the metadata value of the child data system will override the metadata value of the parent data system.

Table 23 – Data Systems Metadata

Metadata Name	Description	Source	Permissions
cdmi_data_redundancy	JSON string containing the desired number of complete copies of the data object to be maintained.	Client	Read/Write
cdmi_immediate_redundancy	JSON string that, if present and set to the value "true", indicates that at least a cdmi_data_redundancy number of copies will contain the newly written value before the operation completes.	Client	Read/Write
cdmi_assignedsize (only valid for a container object – see Chapter 9, “Container Objects”.	JSON string containing the number of bytes that is reported via exported protocols (may be thin provisioned). This number may limit cdmi_size.	Client	Read/Write

Table 23 – Data Systems Metadata

Metadata Name	Description	Source	Permissions
cdmi_infrastructure_redundancy	JSON string containing the desired number of independent storage infrastructures supporting the data.	Client	Read/Write
cdmi_data_dispersion	JSON string containing the desired distance (km) between the infrastructures supporting the multiple copies of data.	Client	Read/Write
cdmi_geographic_placement	JSON array of JSON strings, each containing a geopolitical identifier specifying a region where the object is permitted to or not permitted to be stored. Geopolitical boundaries are a list of ISO-3166 country codes. A "!" in front of a country code excludes that country from the previous list of geopolitical boundaries.	Client	Read/Write
cdmi_retention_id	JSON string containing a user-specified retention identifier	Client	Read/Write
cdmi_retention_period	JSON string containing an ISO-8601 time interval specifying the period the object is to be protected by retention.	Client	Read/Write
cdmi_retention_autodelete	JSON string containing "true" if the object is to be automatically deleted when retention expires.	Client	Read/Write
cdmi_hold_id	JSON array of JSON strings, each containing a user-specified hold identifier. If the array is not empty, the object is under a hold.	Client	Read/Write
cdmi_encryption	JSON string containing the desired encryption algorithm, the mode of operation, and the key size.	Client	Read/Write
cdmi_value_hash	JSON string containing the desired hash algorithm to be used to hash the value of the object. Supported algorithm/length values are provided by the "cdmi_value_hash" capability.	Client	Read/Write
cdmi_max_latency	JSON string containing the desired maximum time to first byte, in milliseconds.	Client	Read/Write
cdmi_max_throughput	JSON string containing the desired maximum data rate on retrieve, in bytes per second.	Client	Read/Write

Table 23 – Data Systems Metadata

Metadata Name	Description	Source	Permissions
cdmi_RPO	JSON string containing the largest acceptable duration in time between an update and when the update can be recovered, in ISO-8601 duration representation.	Client	Read/Write
cdmi_RTO	JSON string containing the largest acceptable duration in time to restore data, in ISO-8601 duration representation.	Client	Read/Write

16.5 Support for Data Copies

CDMI envisions a cloud storage system where multiple primary copies of data are stored and distributed geographically for both availability and performance reasons. All of these primary copies can be accessed through the URI for the object, and the system determines which copy can best satisfy the request. CDMI also envisions secondary copies that are not accessible immediately through the URI but could be used to restore the primary copies, if they were destroyed. The metadata for CDMI data copies are described in Table 24.

Table 24 – Metadata for CDMI Data Copies

Metadata Name	Description
cdmi_data_redundancy	This metadata determines the minimum number of primary copies of the data that the cloud will maintain. Additional primary copies may be made to satisfy demand for the value.
cdmi_immediate_redundancy	This metadata is used to make sure that multiple copies of the data are written to permanent storage to prevent possible data loss. It is tied to the cdmi_data_redundancy metadata value, in that this value determines the number of copies that are written to permanent storage before completing the operation.
cdmi_assignedsize	This metadata is the size that will be shown through any number of data path protocols that are used to export a container. If the container is thin provisioned, this may be greater than the actual storage consumed.
cdmi_infrastructure_redundancy	This metadata is used to convey that, of the primary copies specified in cdmi_data_redundancy, these copies will be stored on this many separate infrastructures. Any two infrastructures cannot share common elements, such as a network or power source.
cdmi_data_dispersion	This metadata is used to separate the (cdmi_infrastructure_redundancy number of) infrastructures by a minimum geographic distance to prevent data loss due to site disasters.
cdmi_geographic_placement	This metadata limits where the data may be placed physically and constrains all cloud movement of the data within the cloud. It does not apply to data once it leaves the cloud. This metadata takes precedent over other metadata, such as cdmi_data_dispersion.
cdmi_retention_id	This metadata is a user-specified text field that is used to tag a given object as being managed by a specific retention policy. It is not required to place an object under retention but is useful when needing to be able to perform a query to find all objects under a specific retention policy.

Table 24 – Metadata for CDMI Data Copies

Metadata Name	Description
cdmi_retention_period	This metadata is the time interval (in either an ISO-8601 date-duration or an ISO-8601 date-date) during which the object is under retention. Only the duration or end-date can be altered when updated. If an object is under retention, the object cannot be deleted and its value cannot be altered. After the retention duration has elapsed, the object can be deleted.
cdmi_hold_id	This metadata is a list of user-specified hold identifiers. If an object is under one or more holds, the object is completely immutable.
cdmi_encryption	This metadata is the desired encryption support that the client is requesting of the cloud. Using the template, ALGORITHM_MODE_KEYLENGTH, the client is able to specify the encryption where: • “ALGORITHM” is the encryption algorithm (e.g., “AES” or “3DES”) • “MODE” is the mode of operation (e.g., “XTS”, “CBC”, or “CTR”) • “KEYLENGTH” is the key size (e.g., “128”, “192”, “256”) To improve interoperability between CDMI implementations, the following designators should be used for the more common encryption combinations: • “3DES_ECB_168” for the three-key Triple DES algorithm, the Cipher Block Chaining (CBC) mode of operation, and a key size of 168 bits • “AES_CBC_128” for the AES algorithm, the CBC mode of operation, and a key size of 128 bits, • “AES_CBC_256” for the AES algorithm, the CBC mode of operation, and a key size of 256 bits, • “AES_XTS_128” for the AES algorithm, the XTS mode of operation, and a key size of 128 bits • “AES_XTS_256” for the AES algorithm, the XTS mode of operation, and a key size of 256 bits
cdmi_max_latency	This metadata is the desired latency (in milliseconds) to the first byte of data in a primary copy, as measured from the edge of the cloud and factoring out any propagation latency between the client and the cloud. For example, this metadata may be used to determine, in an interoperable way, from what type of storage medium the primary copy(s) of the data may be served.
cdmi_max_throughput	This metadata is the desired bandwidth (in Mbits/sec) to the primary copy of data, as measured from the edge of the cloud and factoring out any bandwidth capability between the client and the cloud. This metadata is used to stage the primary data copies in locations where there is sufficient bandwidth to accommodate a maximum usage.
cdmi_RPO	This metadata is used to indicate the desired backup frequency from the primary copy(s) of the data to the secondary copy(s). It is the maximum acceptable duration between a write to the primary copy and the backup to the secondary copy during which a failure of the primary copy(s) will result in data loss.
cdmi_RTO	This metadata is used to indicate the desired maximum acceptable duration to restore the primary copy(s) of the data from a secondary backup copy(s).

16.6 Support for Billed Elements

For each metadata element in a data system, there is an actual value that the offering is able to achieve at this time, as shown in Table 25.

Table 25 – Billed Values of Data Systems Metadata Elements

Metadata Actual Value	Description	Source	Permissions
cdmi_data_redundancy_billed	JSON string containing the current number of complete copies of the data object at this time	Server	Read-Only
cdmi_immediate_redundancy_billed	JSON string, that if present and set to "true", indicates if immediate redundancy is provided for the object.	Server	Read-Only
cdmi_infrastructure_redundancy_billed	JSON string containing the current number of independent storage infrastructures supporting the data currently operating	Server	Read-Only
cdmi_data_dispersion_billed	JSON string containing the current lowest distance (km) between any two infrastructures hosting the data	Server	Read-Only
cdmi_geographic_placement_billed	JSON array of JSON strings, each containing an ISO-3166 identifier that corresponds to a geopolitical region where the object is stored.	Server	Read-Only
cdmi_retention_period	JSON string containing an ISO-8601 time interval specifying the period the object is protected by retention.	Client	Read/Write
cdmi_retention_autodelete	JSON string containing "true" if the object will automatically be deleted when retention expires.	Client	Read/Write
cdmi_hold_id	JSON array of JSON strings, each containing the user-specified hold identifier for active holds.	Client	Read/Write
cdmi_encryption_billed	JSON string containing the algorithm used for encryption, the mode of operation, and the key size. (See cdmi_encryption for the format.)	Server	Read-Only
cdmi_value_hash_billed	JSON string containing the algorithm and length being used to hash the object value.	Server	Read-Only
cdmi_max_latency_billed	JSON string containing the provided maximum time to first byte	Server	Read-Only
cdmi_max_throughput_billed	JSON string containing the provided maximum data rate on retrieve	Server	Read-Only

Table 25 – Billed Values of Data Systems Metadata Elements

Metadata Actual Value	Description	Source	Permissions
cdmi_RPO_billed	JSON string containing the provided duration in time between an update and when the update can be recovered, in ISO-8601 duration representation.	Server	Read-Only
cdmi_RTO_billed	JSON string containing the provided duration in time between an update and when the update can be recovered, in ISO-8601 duration representation.	Server	Read-Only

17 CDMI Logging

Data that is stored in a cloud-based storage system is governed by a similar set of policy, process, and governance regulations, as if the data were being stored on site or in a private cloud. The obligations to a user of cloud-based storage to satisfy regulating agencies, auditors, and IT oversight functions need to be part of the CDMI specification. As the data stored in clouds can span geo-political boundaries, multiple regulations often need to be satisfied to oversight agencies. To accomplish this, CDMI logging is divided into three functional areas, each with differing levels of detail. These include:

- Logging of CDMI object functions
- Logging of security events
- Logging of data management events

Information contained in these logs will be for CDMI operations. Logging of non-CDMI operations is optional, but may be provided through a CDMI logging interface.

17.1 Access to Log Data

A CDMI client can access log data by creating a logging queue that indicates the scope of log messages that they wish to receive, as described in Section 11.1.2, “Logging Queues”. If the user has sufficient permissions to create a log queue, all log messages that he or she has subscribed to will be enqueued into the queue, which can be accessed for processing and archival storage.

If multiple logging queues are defined, each will get the log entry for a subscribed event. If there are no logging queues defined that subscribe to a given log message or class of log messages, these messages do not have to be retained by the system.

17.2 Object Logging

If logging is supported by the storage system, all operations performed on CDMI objects (data objects, containers, domains, queues, and capabilities) must be persistently stored into all defined logging queues.

Log messages must contain a minimum of the following information:

- A timestamp in ISO-8601 format
- The domain in which the operation was performed
- The operation being performed
- The URI of the object against which the operation was performed
- The principal of the entity by which the operation was performed
- The result of the operation

It is anticipated that a standardized format and set of log messages for CDMI operations will be added to a future release of the standard.

Operations logged must include serializations and de-serializations, snapshots, export actions, and mappings of exports to file systems. Operations logged should include operations performed to a CDMI-exported file system.

Any storage consumed by the logging queues should count as part of the overall storage consumed by a domain.

CDMI object logging is a superset of object notifications. Notifications are intended to provide high-level information about changes to objects, to provide less detail than object logging, and to be available to a wider group of end users.

17.3 Security Logging

All security-sensitive events, including session establishment, authentication and authorization, and domain modifications and delegation must be logged as security events. Security logging includes user and domain management, credential-related actions (i.e., revocation list validation) and should include out-of-band operations that affect the security of a CDMI system (such as modifications of security properties of a CDMI domain via an administrative GUI).

17.4 Data Management Logging

In addition to log messages associated with the alteration of metadata when changing data system metadata, logging should also include all conditions where the specified or actual data system metadata for objects change. For example, if the number of requested replicas was changed by a client, this change must generate a log message indicating this change. A corresponding change in the actual number of replicas by the system must also generate a log message.

This class of logging will also contain object holds and retention policy log messages.

17.5 Logging Security Considerations

The accuracy and integrity of the log entries depend on the accuracy and integrity of the clock that is used to set their timestamp values. Accurate timestamps are essential to troubleshooting, forensic analysis of distributed attacks, dispute resolution, and proof of time-sensitive transactions. In essence, debugging, security, audit, and authentication are founded on the basis of event correlation (knowing exactly what happened in what order and on which side), and these security considerations depend on good time synchronization.

While specifying the accuracy and integrity of time keeping is not within the scope of the CDMI standard, to demonstrate that log timestamps are trustworthy, timestamps should be traceable to NIST standard time, and it should be demonstrated that system time cannot be arbitrarily changed.

To ensure that log messages have not been changed, log messages should be signed, such that any changes can be detected and the log integrity can be verified. Log verification also requires the demonstration that messages have not been inserted or removed, requiring the presence of sequence counts or similar methods that demonstrate continuity.

18 Retention and Hold Management

A CDMI system may optionally implement retention management disciplines into the system management functionality of the cloud-based storage system. The implementation of retention and hold capabilities is governed by the presence of the CDMI system-wide capabilities for retention and hold capabilities.

Retention management includes implementing a retention policy, defining a hold policy to enable objects to be held for specific purposes (typically litigation), and defining how the rules for deleting objects are affected by placing either a retention policy and/or a hold on an object. CDMI object deletion is not a capability of retention management, per se, but rather is a general system capability. However, this section describes what happens when placing either a retention policy and/or a hold on an object

Retention management may be applied to the following object types:

- Data objects
- Queue objects
- Container objects

18.1 Retention Management Disciplines

CDMI retention, deletion, and hold management apply to any CDMI application that creates or deletes CDMI objects, as these disciplines mandate how a CDMI system manages CDMI objects when they are created and until they are deleted.

CDMI retention management is comprised of three management disciplines: retention, hold, and deletion:

- CDMI retention uses retention time criteria to determine the time period during which object deletion from the CDMI-based system is prohibited. No changes to the object are allowed; however, extensions of the object metadata are allowed.
- A CDMI-based system shall not allow the deletion of a CDMI object before the CDMI retention time criteria are met, and any deletion tries (e.g., by a CDMI application) shall generate non-fatal errors.
- After the CDMI retention time criteria have been met, CDMI retention shall no longer be a reason to prohibit object deletion.

18.2 CDMI Retention

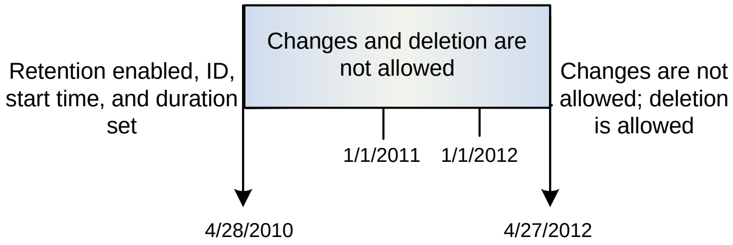
CDMI retention only allows one concurrent retention policy to be applied to an object at a time.

Retention management uses time criteria to determine the time period during which CDMI object deletion from the CDMI-based system shall be prohibited. CDMI retention criteria shall be specified by:

- A retention criteria identifier: a CDMI application-specified string that shall identify the retention records class (cdmi_retention_id)
- A retention start time and retention duration time: the start time, when used together with duration, indicating when retention shall no longer be enforced (cdmi_retention_duration)

When a CDMI application tries to delete an object, the CDMI system shall evaluate all such retention criteria and return a non-fatal error, if any retention criteria have not been met.

Figure 11, “Object Retention” shows how to establish time-based retention with a retention identifier. Object metadata can be extended but not modified.


Changes and deletion are not allowed
Retention enabled, ID, start time, and duration set
Changes are not allowed; deletion is allowed
1/1/2011
1/1/2012
4/28/2010
4/27/2012

Example: Retention start date of 4/18/2010 with a duration of 730 days. No holds.

Figure 11 – Object Retention

A specific HTTP error code (407) will be returned on operations to objects that are under retention period when the CDMI system tries to change or delete the object before the retention duration criteria are met. This failure should be a non-fatal error to the application.

It is not the responsibility of a CDMI system to enforce value changes to the retention duration, as there are valid business reasons to change a retention duration for an object.

18.3 CDMI Hold

CDMI hold enforces read-only data object access and prohibition of object deletion. A CDMI system will allow multiple holds to be applied to a single object to satisfy multiple hold orders.

While an object is on hold, a CDMI system shall:

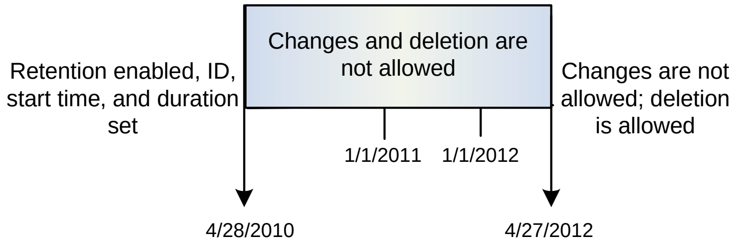
- Strictly enforce read-only access to the object
- Prohibit object deletion

When copying objects that are on hold, hold properties shall not be transferred from the existing CDMI object to the new object, and the new object shall not be on hold.

Hold management uses a hold indicator to determine the time period(s) during which CDMI object revision (data and metadata) and deletion from the CDMI-based system shall be prohibited. CDMI hold criteria shall be specified by data system metadata, specifically, a hold criteria identifier that is an application-specified string that shall identify the holds and their order.

A CDMI application may place an object on hold by adding a hold id to the cdmi_retention_hold data system metadata item. When an object is on hold, CDMI applications shall be subject to failures or unexpected state changes on operations, which would otherwise be successful if the object was not on hold.

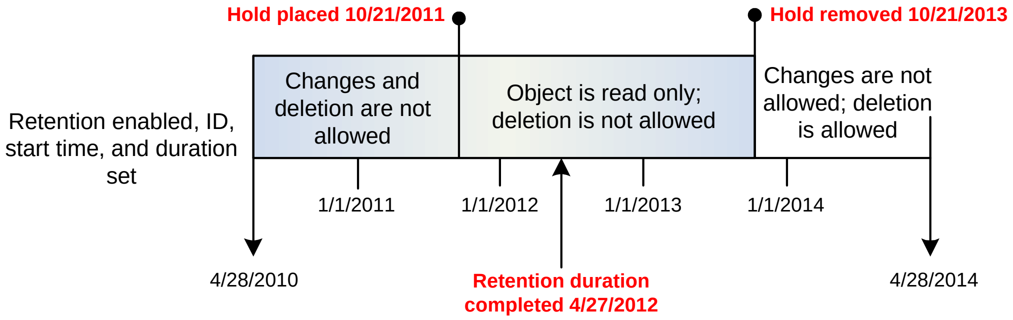
Figure 12, “Object Hold” shows how placing a hold on an object affects its read-only and deletion capability.


Changes and deletion are not allowed
Retention enabled, ID, start time, and duration set
Changes are not allowed; deletion is allowed
1/1/2011
1/1/2012
4/28/2010
4/27/2012

Example: Retention start date of 4/18/2010 with a duration of 730 days. No holds.

Figure 12 – Object Hold

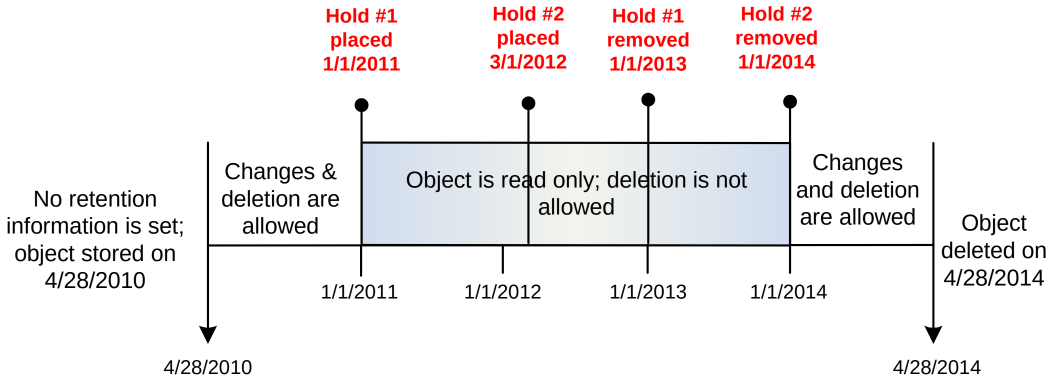
Figure 13, “Object Hold on Object with Retention” shows how to establish time-based retention with a retention identifier that has a hold placed on the object. Object metadata for the retention duration can be extended but not modified.


Hold placed 10/21/2011
Hold removed 10/21/2013
Changes and deletion are not allowed
Object is read only; deletion is not allowed
Changes are not allowed; deletion is allowed
Retention enabled, ID, start time, and duration set
1/1/2011
1/1/2012
1/1/2013
1/1/2014
4/28/2010
Retention duration completed 4/27/2012
4/28/2014

Example: Start date of 4/28/2010 with a duration of 730 days; hold placed on the object

Figure 13 – Object Hold on Object with Retention

Figure 14, “Object with Multiple Holds” shows how placing multiple holds on an object affects its read-only and deletion capability.


Hold #1 placed 1/1/2011
Hold #2 placed 3/1/2012
Hold #1 removed 1/1/2013
Hold #2 removed 1/1/2014
No retention information is set; object stored on 4/28/2010
Changes & deletion are allowed
Object is read only; deletion is not allowed
Changes and deletion are allowed
Object deleted on 4/28/2014
1/1/2011
1/1/2012
1/1/2013
1/1/2014
4/28/2010
4/28/2014

Example: Object created on 4/28/2010.
Hold #1 is placed on 1/1/2011 and removed on 1/1/2013.
Hold #2 is placed on 3/1/2012 and removed on 1/1/2014.

Figure 14 – Object with Multiple Holds

A CDMI system shall maintain an on-hold object in read-only mode with respect to the application access to data and metadata and shall prohibit deletion, either automated or explicit.

- CDMI applications shall tolerate these object on-hold failures or state changes.
- Releases from hold are performed out-of-band or by vendor extension, and are not part of the CDMI specification.

A specific HTTP error code (407) will be returned on operations to objects that are under a hold when the system tries to change the object or tries to delete the object before the hold is removed. This failure should be a non-fatal error to the application.

18.4 CDMI Deletion

CDMI deletion controls CDMI system actions with respect to object deletion. A CDMI system may automatically delete a CDMI object once the retention time and hold criteria have been met. (See **cdmi_retention_autodelete data system metadata**.)

CDMI objects will be automatically deleted by the system by setting the data system metadata flag, cdmi_retention_autodelete, at the retention duration expiration. The cdmi_retention_autodelete flag indicates to the system that the object will be made unavailable for access once the retention criteria have been satisfied. The system will ensure that the object is no longer available through the CDMI interface. If the system has satisfied the retention requirement and a hold is established for the object, the object will not be made unavailable or deleted. When a hold and retention have been applied to an object, both need to be satisfied (retention duration expired and no holds existing) for objects to be automatically deleted from the system.

The autodeletion flag is used with the retention/hold capability of a CDMI system.

18.5 Retention Security Considerations

The accuracy and integrity of the retention start and elapsed times depend on the accuracy and integrity of the clock that is used to set their values. Equally important is the relative accuracy and integrity of the clock, which determines if retention duration has elapsed, to the clock, which sets the start time property. Relative time differences between these two clocks can lead to undesirable retention and deletion management behavior.

It is important to have a reliable source from which the system clock is set. A stratum 1 time is directly connected to a reference clock and is at the top of the time server hierarchy. Relative time differences between the system clock and the reference clock can lead to undesirable retention timestamps and difficulties with time action events. For example, an object is created in an CDMI system at time 0 with duration of 8 years and autodelete of TRUE. At time 1 year, the system clock is adjusted forward to 9 years. Now, because the system time is 9 years, the retention time criterion is satisfied, even though only 1 year has actually elapsed. And, since autodelete is TRUE, the system automatically deletes the object.

The specification for accuracy and integrity of timekeeping is not within the scope of CDMI. However, to prevent undesirable retention and deletion management consequences, systems are strongly encouraged to maintain accurate clock time, with zero or minimal deviation to clock integrity.

Annex A
(normative)
Transport Security

For most CDMI implementations, the Hypertext Transfer Protocol (HTTP) is the underlying communications protocol used to transfer CDMI messages. This appendix identifies the details associated with securing this underlying transport.

A.1 General Requirements for HTTP Implementations

The security requirements for HTTP implementations apply to both CDMI servers and clients. A CDMI client shall comply with all security requirements for HTTP that apply to clients. The following general requirements support security when using HTTP.

- Either HTTP basic authentication or HTTP digest authentication should be implemented.
- To minimize compromising user identities and credentials, such as passwords, implementations should use HTTP basic authentication ONLY in conjunction with Transport Layer Security (TLS).
- A user identity and credential used with one type of HTTP authentication (i.e., basic or digest) should never be subsequently used with the other type of HTTP authentication. To avoid compromising the integrity of a stronger scheme, established good security practices avoids the reuse of identity and credential information across schemes of different strengths.
- TLS 1.1 shall be implemented by CDMI entities and TLS 1.2 is strongly encouraged. The use of TLS by CDMI entities is optional, but should be used to protect sensitive data.

When HTTP over TLS is implemented, then the following requirements apply:

- When TLS is implemented, the following cipher suites shall be supported to ensure a minimum level of security and interoperability between implementations:

  — TLS_RSA_WITH_AES_128_CBC_SHA (mandatory for TLS 1.1/1.2)

  — TLS_RSA_WITH_AES_256_CBC_SHA256 (addresses 112-bit security strength requirements)

  — TLS_RSA_WITH_NULL_SHA (for TLS without encryption)

  Note: Implementers are free to include additional cipher suites, but there is no guarantee of interoperability when they are used.

- For clients and servers to communicate, they need to be using a consistent approach to security. Properly configured clients and servers may fail to communicate, if one is relying on port 80 and the other on port 443. Clients that fail to connect to a CDMI server via HTTP over TLS on TCP port 443 should retry with HTTP on TCP port 80 if their security policy allows it.
- Servers may accelerate discovery that a secure channel is needed by responding to HTTP contacts on TCP port 80 with a HTTP REDIRECT to the appropriate HTTPS: URL (HTTP over

TLS on TCP port 443) to avoid the need for clients to timeout the HTTP contact attempt. Clients should honor such redirects in this situation.

— All certificates, including CA Root Certificates used by clients for certificate validation, shall be replaceable.

— The DER encoded X.509, Base64 encoded X.509, and PKCS#12 certificate formats shall be supported.

— Certificate Revocation Lists shall be supported in the DER encoded X.509 and Base64 encoded X.509 formats.

Note: Since there are no absolutes when it comes to security, when specified versions are found to be vulnerable and/or inadequate, CDMI implementations should move to a newer version of TLS and stronger cipher suites as soon as possible.

A.2 Basic HTTP Security

HTTP is the mandatory transport mechanism for this version of CDMI. It is important to note that HTTP, by itself, offers no confidentiality or integrity protections.

CDMI clients may be responsible for initiating user authentication for each CDMI server that a user accesses. The CDMI server functions as the authenticator, and it receives the user credentials from the HTTP authentication operations.

IETF RFC 2616 and IETF RFC 2617 define requirements for HTTP authentication, which generally starts with an HTTP client request, such as "GET Request-URI" (where Request-URI is the resource requested). If the client request does not include an "Authorization" header line and authentication is required, the server responds with a "401 Unauthorized" status code, and a "WWW-Authenticate" header line. The HTTP client shall then respond with the appropriate "Authorization" header line in a subsequent request. The format of the "WWW-Authenticate" and "Authorization" header lines varies depending on the type of authentication required—basic authentication or digest authentication. If the authentication is successful, the HTTP server will respond with a status code of "200 OK".

Basic authentication involves sending the user name and password in the clear, and it should only be used on a secure network or in conjunction with a mechanism that ensures confidentiality, such as TLS (see Section A.3, “HTTP over TLS (HTTPS)”. Digest authentication sends a secure digest of the user name and password (and other information including a nonce value), so that the password is not revealed. "401 Unauthorized" responses should not include a choice of authentication.

Client authentication to the CDMI server is based on an authentication service (local and/or external). Differing authentication schemes may be supported, including host-based authentication, Kerberos, PKI, or other; the authentication service is out scope of this specification.

A.3 HTTP over TLS (HTTPS)

CDMI may also include a mechanism to secure HTTP communications, such that data sent between the clients and servers are encrypted before being sent over the network. This security is achieved by transmitting HTTP over TLS (also known as HTTPS); the URL of a secure connection will begin with https://
instead of http://. It is also important to note that a CDMI client communicates with a CDMI server via HTTPS on TCP port 443 (TCP port 80 is used for HTTP). Section A.3.1, “Transport Layer Security (TLS)” provides important details on TLS.

When TLS is used to secure HTTP, the client and server typically perform some form of entity authentication. However, the specific nature of this entity authentication depends on the cipher suite negotiated; a cipher suite specifies the encryption algorithm and digest algorithm to use on a TLS connection. A very common scenario involves the use of server-side certificates, which the client trusts, as the basis for unidirectional entity authentication. It is possible that no authentication will occur (e.g., anonymous authentication) or on the other extreme, mutual authentication involving both client-side and server-side certificates may be required.

A.3.1 Transport Layer Security (TLS)

While CDMI implementations are required to implement the Transport Layer Security (TLS) protocol, its use is optional. TLS 1.1, which is the mandatory version, is specified in [RFC 4346] and the optional TLS 1.2 is specified in [RFC 5246].

The primary goal of the TLS protocol is to provide privacy and data integrity between two communicating applications. TLS allows client/server applications to communicate in a way that is designed to prevent eavesdropping, tampering, or message forgery. TLS is layered on top of some reliable transport protocol (e.g., TCP), and it is used for encapsulation of various higher-level protocols (e.g., HTTP).

TLS provides endpoint authentication and communications privacy over the network using cryptography. Typically, only the server is authenticated (i.e., its identity is ensured) while the client remains unauthenticated; this means that the end user (whether an individual or an application) has a measure of assurance with whom they are communicating. Mutual authentication (the identities of both endpoints are verified) requires, with few exceptions, the deployment of digital certificates on the client.

TLS involves three basic phases:

- Peer negotiation for algorithm support
- Key exchange and authentication
- Symmetric cipher encryption and message authentication

During the first phase, the client and server negotiate *cipher suites* (see Section A.3.1.1, “Cipher Suites”), which determine the ciphers to be used, the key exchange, and authentication algorithms, as well as the message authentication codes (MACs). The key exchange and authentication algorithms are typically public key algorithms. The MACs are made up from a keyed-Hash Message Authentication Code, or HMAC.

A.3.1.1 Cipher Suites

TLS packages one key establishment, confidentiality, signature and hash algorithm into a "cipher suite." A registered 16-bit (4 hexadecimal digit) number, called the cipher suite index, is assigned for each defined cipher suite. For example, RSA key agreement, RSA signature, Advanced Encryption Standard (AES) using Cipher Block Chaining (CBC) confidentiality, and the Secure Hash Algorithm (SHA-1) hash are assigned the hexadecimal value {0x000F} for TLS. Note especially that TLS 1.1 requires (see [RFC 4346] Section 9 – *Mandatory Cipher Suites*): "In the absence of an application profile standard specifying otherwise, a TLS compliant application shall implement the cipher suite TLS_RSA_WITH_AES_128_CBC_SHA" described above.

The client always initiates the TLS session and starts cipher suite negotiation by transmitting a handshake message that lists the cipher suites (by index value) that it will accept. The server responds with a handshake message indicating which cipher suite it selected from the list or an "abort" as described below. Although the client is required to order its list by increasing "strength" of cipher suite, the server may choose ANY of the cipher suites proposed by the client. Therefore, there is NO guarantee that the negotiation will select the strongest suite. If no cipher suites are mutually supported, the connection is aborted. When the negotiated options, including optional public key certificates and random data for developing keying material to be used by the cryptographic algorithms, are complete, messages are exchanged to place the communications channel in a secure mode.

To ensure a minimum level of security and interoperability between implementations, all CDMI clients and servers that support HTTPS shall implement the TLS_RSA_WITH_AES_128_CBC_SHA cipher suite, which is also the mandatory cipher suite for TLS 1.1 (see [RFC 4346] Section 9 – *Mandatory Cipher Suites*). Inclusion of the TLS_RSA_WITH_NULL_SHA256 cipher suite (hexadecimal value {0x003B}) is also required for both CDMI clients and servers when encrypted communications are not needed. In addition, the TLS_RSA_WITH_AES_128_CBC_SHA256 cipher suite (hexadecimal value {0x003C}) is required to meet the transitions to a security strength of 112 bits (guidance is provided in NIST Special Publication 800-57). Implementers are free to include additional cipher suites.

A.3.1.2 Digital Certificates

CDMI clients and servers may be attacked by setting up a false CDMI server to capture userids and passwords or to insert itself as an undetected proxy between a CDMI client and server. The most effective countermeasure for this attack is the controlled use of server certificates with TLS, matched by client controls on certificate acceptance on the assumption that the false server will be unable to obtain an acceptable certificate. Specifically, this could be accomplished by configuring clients to always use TLS underneath HTTP authentication, and only accept certificates from a specific local certificate authority.

When used by CDMI, TLS shall use X.509 version 3 public key certificates that conform to the Certificate and Certificate Extension Profile defined in Section 4 of [RFC 3280] (X.509v3 Certificate and CRL). This certificate and certificate revocation list (CRL) profile specifies the mandatory fields that shall be included in the certificate, as well as optional fields and extensions that may be included in the certificate.

Server certificates shall be supported by all CDMI servers, and client certificates may be supported by CDMI clients. The server presents a server certificate to authenticate the server to the client; likewise, the client presents a client certificate to authenticate itself to the server. For public web sites offering secure communications via TLS, server certificate usage is quite common, but client certificates are rarely used, because the client is typically authenticated by other means. For example, an e-commerce site will authenticate a client by a credit card number, user name/password, etc., when a purchase is made. It is much more of a trust issue that the client (purchaser) be assured of the identity of the e-commerce site, and for this reason, server certificates are much more commonly encountered in practice.

These X.509 certificates use a digital signature to bind together a public key with an identity. These signatures will often be issued by a certification authority (CA) that is associated with an internal or external public key infrastructure (PKI); however, an alternate approach uses self-signed certificates (the certificate is digitally signed by the very same key-pair whose public part appears in the certificate data). The trust models associated with these two approaches are very different. In the case of PKI certificates, a hierarchy of trust and a trusted third-party can be consulted in the certificate validation process, which enhances security at the expense of increased complexity. The self-signed certificates can be used to form a web of trust (trust decisions are in the hands of individual users/administrators), but is considered less secure, as there is no central authority for trust (e.g., no identity assurance or revocation). This reduction in overall security, which may still offer adequate protections for some environments, is accompanied by an easing of the overall complexity of implementation.

With PKI certificates, it is often necessary to traverse the hierarchy or chain of trust in search of a root of trust or trust anchor (a trusted CA). This trust anchor may be an internal CA, which has a certificate signed by a higher ranking CA, or it may be the end of a certificate chain as the highest ranking CA. This highest ranking CA is the ultimate attestation authority in a particular PKI scheme and its certificate, known as a root certificate, can only be self-signed. Establishing a trust anchor at the root certificate level, especially for commercial CAs, can have undesirable side effects resulting from the implicit trust afforded all certificates issued by that commercial CA. Ideally the trust anchor should be established with the lowest ranking CA that is practical.

A.3.1.2.1 Certificate Validation

CDMI clients and servers shall perform basic path validation, extension path validation, and Certificate Revocation List (CRL) validation as specified in Section 6 of [RFC3280] for all presented certificates. These validations include, but are not limited to, the following:

- The certificate is a validly constructed certificate.
- The signature is correct for the certificate.
- The date of its use is within the validity period (i.e., it has not expired).
- The certificate has not been revoked (applies only to PKI certificates).
- The certificate chain is validly constructed (considering the peer certificate plus valid issuer certificates up to the maximum allowed chain depth (applies only to PKI certificates).

When CDMI clients and servers use CRLs, they shall use X.509 version 2 CRLs that conform to the CRL and CRL Extension Profile defined in Section 5 of [RFC3280], (This requirement also only applies to PKI certificates.)

When PKI certificates and self-signed certificates are used together in a single management domain, it is important to recognize that the level of security is lowered to that afforded by self-signed certificates. Self-signed certificates by themselves only offer the keying materials to allow confidentiality and integrity in communications. The only identity assurances for self-signed certificates lie in the processes governing their acceptance as described below.

A.3.1.2.2 Certificate Formats

All interfaces for certificate configuration (import in particular) shall support the following certificate formats:

- DER encoded X.509. See [ITU-T509] for specification and technical corrigenda.

  International Telecommunications Union Telecommunication Standardization Sector (ITU-T), Recommendation X.509: Information technology - Open Systems Interconnection - The Directory: Public-key and attribute certificate frameworks, May 2000. Specification and technical corrigenda can be obtained from: http://www.itu.int/ITU-T/publications/recs.html

- Base64 encoded X.509 (often called PEM). See Section 6.8 of [RFC2045].

  N. Freed and N. Borenstein, Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies, IETF RFC 2045, November 1996, Section 6.8. Available at: http://www.ietf.org/rfc/rfc2045.txt

- PKCS#12. See [PKS12] for specification and technical corrigenda.

All certificate validation software shall support local certificate revocation lists, and at least one list per CA root certificate supported. Support is required for both DER encoded X.509 and Base64 encoded X.509 formats, but this support may be provided by using one format in the software and providing a tool to convert lists from the other format. OCSP and other means of immediate online verification of certificate validity are optional, as connectivity to the issuing Certificate Authority cannot be assured.

A.3.1.2.3 Certificate Management

All certificates identifying CDMI entities and their associated private keys shall be replaceable. CDMI clients and servers shall either 1) have the ability to import an externally generated certificate and corresponding private key or 2) have the ability to generate and install a new self-signed certificate along with its corresponding private key.

When CDMI clients and servers use PKI certificates, the implementations shall include the ability to import, install/store, and remove the CA root certificates; support for multiple trusted issuing CAs shall be included. CA certificates are used to verify that a certificate has been signed by a key from an acceptable certification authority.

All certificate interfaces required above shall support access restrictions that permit access only by suitably privileged administrators. A suitably privileged security administrator shall be able to disable functionality for acceptance of unrecognized certificates described in Section A.3.1.2.1, “Certificate Validation” and Section A.3.1.2.2, “Certificate Formats”.

The above requirements can be satisfied via appropriate use of the readily-available OpenSSL toolkit software (www.openssl.org). Support for PKCS#7 certificate format was deliberately omitted from the requirements. This format is primarily used for online interaction with certificate authorities; such functionality is not appropriate to require of all CDMI software, and tools are readily available to convert PKCS#7 certificates to or from other certificate formats.

A.3.1.2.4 Digital Certificate Guidance for TLS

To facilitate the use of certificates, CDMI implementations should include configurable mechanisms that allow for one of the following mutually exclusive operating modes to be in force at any time for end-entity certificates (i.e., not CA certificates):

- Unverifiable end-entity (self-signed) certificates are automatically installed as trust anchors when they are presented; such certificates shall be determined to not be CA root certificates prior to being installed as trust anchors and shall not serve as trust anchors to verify any other certificates. If a CA certificate is presented as an end-entity certificate in this mode, it shall be rejected. For CDMI clients, a variant of this option, which consults the user before taking action, should be implemented and used when possible.

  Note: The use of this operating mode should be limited to a learning or enrollment period during which communication is established with all other CDMI systems with which security communication is desired. Use of a timeout to force automatic exit from this mode is recommended.

- Unverifiable end-entity (self-signed) certificates can be manually imported and installed as trust anchors (in a fashion similar to manually importing and installing a CA root certificate), but they are not automatically added when initially encountered. Administrative privilege may be required to import and install an end-entity certificate as a trust anchor.

  This is considered the normal operating mode. All certificate acceptance policies for CDMI clients and servers shall be configurable. The configurable mechanisms determine how the CDMI implementation handles presented certificates. Under normal operating mode, CDMI servers should not accept certificates from unknown trust authorities (i.e., the CA root certificate has not been installed).

Interactive clients should provide a means to query the user about acceptance of a certificate from an unrecognized certificate authority (no corresponding CA root certificate installed in client), and accept responses allowing use of the certificate presented, or all certificates from the issuing CA. Servers should not support acceptance of unrecognized certificates; it is expected that a limited number of CAs will be acceptable for client certificates in any site that uses them.

Pre-configuring root certificates from widely used CAs is optional, but simplifies initial configuration of certificate-based security, as certificates from those CAs will be accepted. These CA root certificates can be exported from widely available web browsers.

Annex B
(Informative)
Extending the Interface

This appendix contains information on how to extend the interface standard to cover additional capabilities of offerings.