Jobs CDMI Extension

Version 2.0

ABSTRACT: This CDMI Extension is intended for developers who are considering a standardized way to add functionality to CDMI. When multiple compatible implementations are demonstrated and approved by the Technical Working Group, this extension will be incorporated into the CDMI standard.

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 Working Draft

June 17, 2020
Jobs CDMI Extension 2.0

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 Clause 1

Jobs CDMI Extension

1.1 Overview

Some CDMI systems allow jobs (such as deletion, changing metadata, scanning for viruses, etc.) to be performed against CDMI objects. In such a system, multiple jobs may be performed simultaneously against the same or multiple objects. In these systems, the client needs to be able to track the status of a job separately from the objects on which the jobs act. Jobs may also be batched, and a method is needed to track the status for the batch job independently of individual jobs that comprise the batch job.

This extension proposes a new type of data object to handle these requirements. The job data object (extended in a similar manner as a query queue object) may be used to define, perform, and track job status independently from the objects on which the job is acting.

1.2 Instructions to the Editor

To merge this extension into the CDMI 2.0.0 specification, make the following changes:

1. Insert into preamble/terms.txt, as follows:

   job |br| a data object that defines and manages one or more job actions that may be performed against one or more CDMI objects (job targets) |br|

   job action |br| a specific change in state performed on a per CDMI object basis as a consequence of a job being run against a CDMI object

   Note: Examples include deletion, metadata changes, thumbnail creation, etc. |br|

   job container |br| a CDMI container object that is capable of storing CDMI job objects |br|

   job state |br| a value used to control the runtime state of a job

   Note: Examples include start, stop, and cancel. |br|

   job target |br| the set of CDMI objects against which a job performs actions |br|

2. Add an entry to the end of the table starting on line 135 of cdmi_advanced/cdmi_capability_object.txt, as follows:
### Jobs CDMI Extension 2.0

#### Table 1: System-wide capabilities

<table>
<thead>
<tr>
<th>Capability name</th>
<th>Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdmi_jobs</td>
<td>JSON string</td>
<td>If present and &quot;true&quot;, the CDMI server supports job data objects.</td>
</tr>
<tr>
<td>cdmi_jobs_global_container</td>
<td>JSON string</td>
<td>If present and &quot;true&quot;, contains the URI for the container for all job data objects in the CDMI server.</td>
</tr>
</tbody>
</table>

3. Add an entry to the end of the table starting on line 451 of cdmi_advanced/cdmi_capability_object.txt, as follows:

#### Table 2: Capabilities for data system metadata

<table>
<thead>
<tr>
<th>Capability name</th>
<th>Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdmi_job_container_actions</td>
<td>JSON array of JSON strings</td>
<td>If present, lists the job action strings that may be requested for child job data objects created within a given container.</td>
</tr>
</tbody>
</table>

4. Add an entry to the end of the table starting on line 612 of cdmi_advanced/cdmi_capability_object.txt, as follows:

#### Table 3: Capabilities for data objects

<table>
<thead>
<tr>
<th>Capability name</th>
<th>Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdmi_job_states</td>
<td>JSON array of JSON strings</td>
<td>If present, lists the job state strings that may be specified by a client.</td>
</tr>
</tbody>
</table>

5. Add an entry to the end of the table starting on line 662 of cdmi_advanced/cdmi_capability_object.txt, as follows:

#### Table 4: Capabilities for container objects

<table>
<thead>
<tr>
<th>Capability name</th>
<th>Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdmi_create_job_container</td>
<td>JSON array of JSON strings</td>
<td>If present, indicates that the container allows the creation of job container objects and shall list the job action strings supported for child job containers.</td>
</tr>
<tr>
<td>cdmi_create_job_dataobject</td>
<td>JSON string</td>
<td>If present and &quot;true&quot;, indicates that the container allows the creation of job data objects.</td>
</tr>
</tbody>
</table>

6. Add an entry to the end of the table starting on line 216 of cdmi_advanced/cdmi_metadata.txt, as follows:

#### Table 5: Data system metadata

<table>
<thead>
<tr>
<th>Metadata name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdmi_job_container.actions</td>
<td>JSON array of JSON strings</td>
<td>Contains a list of requested job actions to be permitted for job data objects created in the container. The job action strings that may be requested are indicated in the &quot;cdmi_job_container_actions&quot; capability of the parent container. If all supported actions are to be requested, the string &quot;ALL&quot; shall be used.</td>
</tr>
</tbody>
</table>

7. Add an entry to the end of the table starting on line 533 of cdmi_advanced/cdmi_metadata.txt, as follows:

#### Table 6: Provided values of data system metadata

<table>
<thead>
<tr>
<th>Metadata name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdmi_job_container.actions_provided</td>
<td>JSON array of JSON strings</td>
<td>Contains a list of job actions that are permitted for job data objects created in the container.</td>
</tr>
</tbody>
</table>

Clause 2

Jobs

2.1 Job Management

A cloud storage system may optionally implement job management functionality. Job implementation is indicated by the presence of the cloud storage system-wide capabilities for jobs and requires support for CDMI data objects.

Jobs allow arbitrary system-defined actions (such as deletion, metadata changes, thumbnail creation, virus scanning, etc.) to be performed against one or more stored CDMI objects. In addition, multiple jobs may perform actions against a single CDMI object. By creating a well-defined “job” object, clients may define jobs, specify which action is to be performed, specify which objects the action is to be performed against, monitor the status, and control the operation of the job in an interoperable and extensible manner.

In addition, multiple jobs may be batched together to apply actions sequentially for each target CDMI object. Such a batch job may affect multiple objects, and each job may progress at a different rate. The client cares about the overall status of its job, not the status on each object that the job affects. Tracking the job completion status in the completionStatus and percentComplete fields of the data object as described in clause %s is not adequate for such systems.

These problems are solved by tracking the job status in a separate CDMI job data object. The job data object provides access to the completion status and percent complete of the job itself, along with other information required to define, monitor, and control the job.

Jobs may be stored in container objects or may exist as standalone data objects with no parent container.

Cloud storage systems should consider implementing support for job data objects when the system supports the following types of client-controlled activities:

- Server-side transformative operations: If the system allows a client to request that an operation be performed against a CDMI data object, the user should initiate and manage the operation through the jobs interface.
- Batch jobs: When running batch jobs that include multiple individual actions, the user needs to track the status for the jobs as the aggregate of the independent tasks.
- Multi-threading: If it is possible for multiple jobs to be performed on the same object simultaneously, the user needs to track the status of each job independently.
- Long-running jobs: If jobs are run continuously, the user needs to be able to monitor and control the job.
2.2 Job Creation

When a client wishes to create a job data object, it may first check if the system is capable of providing job functionality by checking for the presence of the `cdmi_jobs` capability in the root container capabilities. If this capability is not present, creating a job data object shall be successful, but no job action shall be performed.

Jobs may be created by CDMI clients and CDMI server internal processes.

Examples of jobs created by CDMI clients may include:
- deleting data,
- updating metadata, and
- serialization.

Examples of jobs created by internal system processes may include:
- data migration,
- virus scans,
- search indexing, and
- periodic backups.

CDMI clients may create jobs through a variety of methods:

- A client may create a job data object without specifying a location by performing a POST operation. In this case, the system shall create the job in a job container and return an HTTP response code of 202 Accepted. The URI for newly created job object shall be returned in an HTTP `Location` response header.
- A client may create a job data object at a specific location by performing a PUT operation. Only containers with a `cdmi_job_dataobject` capability shall allow job data objects to be created. The semantics for this are the same as other data objects.
- A client may view and access jobs created by internal system processes through the job container. To get a list of system-created jobs, clients may list the children of the container.

2.3 Job Object Metadata

When a client creates a job data object, the presence of the metadata item `cdmi_job_state` indicates that the data object represents a job.

Metadata, including the `cdmi_job_state` metadata item may be changed by a client. If the `cdmi_job_state` metadata item is removed, that indicates that the job data object shall no longer manage jobs; instead, it shall be treated as a regular CDMI data object by the CDMI server.

The metadata items for a job data object are shown in Table 7.

<table>
<thead>
<tr>
<th>Job Metadata Item</th>
<th>Type</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>cdmi_job_state</code></td>
<td>JSON string</td>
<td>Controls the desired runtime state of the job. Defined values are one of the following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Start indicates that the job shall be transitioned to the Processing state.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Pause indicates that the job shall be transitioned to the Idle state.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Cancel indicates that the job shall be transitioned to the Canceled state.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only values specified in the <code>cdmi_job_states</code> capability shall be accepted by the CDMI server.</td>
<td></td>
</tr>
</tbody>
</table>

Mandatory
<table>
<thead>
<tr>
<th>Job Metadata Item</th>
<th>Type</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdmi_job_status</td>
<td>JSON</td>
<td>A string that indicates the status of the job using one of the following values.</td>
<td>Mandatory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Pending indicates that the job object has been created but has not yet started running.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Processing indicates that the job is acting against the specified targets.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Idle indicates that the job has completed acting against the specified targets and will resume if additional targets are specified.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Complete indicates that the job has completed acting against the specified targets and will not resume.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Canceled indicates that the job was canceled before it acted against all of the specified targets.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• A string that begins with “Error” indicates that an error prevented the job from acting against one or more of the specified targets.</td>
<td></td>
</tr>
<tr>
<td>cdmi_job_detailStatus</td>
<td>JSON</td>
<td>A message indicating what the job is currently doing or indicating the details about the error if it failed.</td>
<td>Optional</td>
</tr>
<tr>
<td>cdmi_job_percentComplete</td>
<td>JSON</td>
<td>The value shall be an integer numeric value from 0 through 100.</td>
<td>Optional</td>
</tr>
<tr>
<td>cdmi_job_startTime</td>
<td>JSON</td>
<td>When present, this metadata item indicates the time when the job started in ISO-8601 format (see %s).</td>
<td>Optional</td>
</tr>
<tr>
<td>cdmi_job_endTime</td>
<td>JSON</td>
<td>When present, this metadata item indicates the time when the job completed, was halted, or went into an error status in ISO-8601 format (see %s).</td>
<td>Optional</td>
</tr>
</tbody>
</table>

### 2.4 Job Object Value

When a client creates a job data object, the JSON fields described in Table 127 shall be provided as the value of the data object.

The value of a job data object shall be immutable once created.

The value of a job data object are shown in Table 8.

<table>
<thead>
<tr>
<th>Job Value JSON item</th>
<th>Type</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>cdmi_job_action</td>
<td>JSON</td>
<td>A system-defined identifier that indicates what action should be performed against each CDMI object that the job targets.</td>
<td>Mandatory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Job actions defined as part of the CDMI specification (see 2.7) begin with the prefix cdmi_job_action_.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Job actions defined by vendors should begin with a reverse DNS notation such as org.snia. to prevent namespace conflicts.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only job actions specified in the data system metadata items listed in cdmi_job_container_actions_provided of the parent container of the job data object shall be supported.</td>
<td></td>
</tr>
</tbody>
</table>
Table 8 – continued from previous page

<table>
<thead>
<tr>
<th>Job Value JSON item</th>
<th>Type</th>
<th>Description</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>cdmi_job_action_params</code></td>
<td>JSON object or JSON array</td>
<td>Contains job action-specific parameters that control how a job action behaves. [.. raw:: latex \vspace*{1ex}] For example, a thumbnail action may take parameters that indicate the height and width and/or desired size, output format, etc.</td>
<td>Optional</td>
</tr>
<tr>
<td><code>cdmi_job_target</code></td>
<td>JSON array of JSON strings</td>
<td>Indicates against which CDMI objects the job action is performed. [.. raw:: latex \vspace*{1ex}] Contains either an array of URIs to CDMI objects against which the job action shall be performed or a single URI to a CDMI queue. Each value enqueued in the queue is a URI to a CDMI object against which the job action shall be performed. For details on how queues are used with jobs, see FIXME.</td>
<td>Mandatory</td>
</tr>
<tr>
<td><code>cdmi_job_results</code></td>
<td>JSON string</td>
<td>Contains the URI to a CDMI queue that is used to indicate the results of performing a job. If present, the job shall enqueue a job-defined result value of performing the action against each job target.</td>
<td>Optional</td>
</tr>
<tr>
<td><code>cdmi_job_autodelete</code></td>
<td>JSON string</td>
<td>Contains the length of time in seconds the job data object shall be retained after the job status transitions to “Complete” or “Canceled”. If this field is not present, the job shall not be automatically deleted.</td>
<td>Optional</td>
</tr>
<tr>
<td><code>cdmi_job_scheduleTime</code></td>
<td>JSON string</td>
<td>The earliest time that the job shall run, specified in ISO-8601 format (see %s). The job shall be scheduled to run as soon as possible if this field is omitted or if the time specified is earlier than the current system time.</td>
<td>Optional</td>
</tr>
</tbody>
</table>

### 2.5 Examples

**EXAMPLE 1:** A CDMI job value that deletes three CDMI objects, then immediately deletes itself:

```json
{
    "cdmi_job_action" : "cdmi_job_action_delete",
    "cdmi_job_target" : [
        "/cdmi_objectid/00007ED900100DA32EC94351F8970400",
        "/cdmi_objectid/00007ED90010F077F4EB1C99C87524CC",
        "/cdmi_objectid/00007ED90010512EB55A9304EAC5D4AA"
    ],
    "cdmi_job_autodelete" : "0"
}
```

**EXAMPLE 2:** A CDMI job value that deletes every object enqueued into a notification queue:

```json
{
    "cdmi_job_action" : "cdmi_job_action_delete",
    "cdmi_job_target" : "/container/jobs/created_mp3_files_queue"
}
```

Jobs may be used in combination with query and notification queues to perform an action against each query result or notification result.
2.6 Job Lifecycle

The defined job status and transitions between status is shown in Fig. 1.

Fig. 1: Job Lifecycle

* Denotes states that can be controlled through the cdmi_job_state metadata item

The following status values will be reflected in the cdmi_job_status field of the job data object:

Pending, Active, Idle, Completed, Error, and Canceled.

The job is created in the Pending state. If it is started, it moves to the Active state. The job may optionally move between the Active and Idle states; however, all systems may not support the Idle state. The job moves to Completed, Error, or Canceled once it is finished. The Canceled state is optional, as it may not make sense in some systems. After completion, the job is retained until the client deletes the job or until the cdmi_job_autodelete period elapses. The system shall permit the client to start, pause, restart, or cancel a job using the cdmi_job_state metadata item. This functionality is optional, as the ability to directly control a job depends on the system.

2.7 Job Actions

A client shall use the cdmi_jobs_actions system-wide capability to discover which job actions are supported.

Job actions defined in this international standard are shown in Table 9.

Table 9: Job actions

<table>
<thead>
<tr>
<th>Job Action</th>
<th>Description</th>
</tr>
</thead>
</table>
| cdmi_job_action_sequential_batch          | Sequential batch jobs perform two or more jobs one after another against each targeted CDMI object in a specified order.  
• Sequential batch jobs have the job action identifier of cdmi_job_action_batch_sequential.  
• The action parameters are an ordered JSON array of URIs to other job data objects that define the individual operations to be performed.  
Each of these component jobs shall not have a job_target or job_state, as the job_target and job_state of the sequential batch job shall be used instead. |

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### 2.8 Job Containers

CDMI job container objects store job data objects. Use of job containers is optional in CDMI systems but is mandatory if clients are permitted to create job data objects.

Job containers may be dedicated to storing only job data objects, or they may store other containers and data objects, including job data objects. CDMI systems may automatically create job containers, and in such systems, CDMI clients may not have the ability to create or delete job containers. Other systems may allow CDMI clients to create or delete job containers that support storing job data objects that the system or CDMI clients create.

A CDMI system may create and implement a single, global jobs container that CDMI clients may not change. If present, clients locate this global jobs container by the URI specified by the `cdmi_jobs_global_container` capability described in §§.

Systems may allow multiple job containers. Jobs may be grouped in containers along with non-job data objects. One use of multiple containers is to group jobs by type. Systems may allow CDMI clients to create their own job containers.

When job containers are supported, a CDMI client shall identify job containers using the `cdmi_job_container_actions` data system metadata capability described in §§.

The ability of a CDMI client to create a job container object within a container is indicated by the `cdmi_create_job_container` container capability described in §§. This capability also indicates any restrictions on job actions for a created child job container.

Once a job container has been created, the data system metadata of the `cdmi_job_container_actions_provided` contains an array of JSON strings that indicate the allowable actions that may be requested for job data objects that are created within that job container (see §§). The system generates this list depending on which actions are supported and which actions are requested in the data system metadata of the `cdmi_job_container_actions` described in §§.

A system may allow jobs to be created or deleted within a job container. This function is indicated by the capabilities associated with the job container.

---

<table>
<thead>
<tr>
<th>Job Action</th>
<th>Description</th>
</tr>
</thead>
</table>
| `cdmi_job_action_parallel_batch` | Parallel batch jobs perform two or more individual jobs in any order or at the same time against each targeted CDMI object. Parallel batch jobs should only perform job actions that do not alter the target data objects, or unspecified results may occur.  
- Parallel batch jobs have the job action identifier of `cdmi_job_action_batch_parallel`.  
- The action parameters are a JSON array of URIs to other job data objects that define the individual operations to be performed.  
Each of these component jobs shall not have a `job_target` or `job_state`, as the `job_target` and `job_state` of the parallel batch job shall be used instead. |
| `cdmi_job_action_delete` | Deletion jobs delete the target CDMI objects.  
- Delete jobs have the job action identifier of `cdmi_job_action_delete`.  
- No job action parameters are required. |
| `cdmi_job_action_update_metadata` | Update metadata jobs manipulate the metadata of target CDMI objects.  
- Update metadata jobs have the job action identifier of `cdmi_job_action_update_metadata`.  
- The action parameters are an JSON object that contain or more of the below three JSON containers:  
  - The `update_add` contains metadata items to be added to the data object if they don’t already exist;  
  - The `update_modify` contains metadata items to be overwritten if they already exist; and  
  - The `update_delete` contains metadata items to be removed from the data object. |
• The ability of a CDMI client to create a job data object within a job container is indicated by the `cdmi_create_job_dataobject` container capability described in §s.

• The ability of a CDMI client to delete a job data object within a job container is indicated by the `cdmi_delete_dataobject` data object capability described in §s.

Using capabilities and data system metadata, the client follows these steps to create a new job container that allows jobs for deleting CDMI objects:

1. Examine the presence and value of the `cdmi_create_job_container` capability of the parent container to see if child job containers may be created and if the `cdmi_job_action_delete` action is supported.

2. If job container creation is supported and the `cdmi_job_action_delete` action is supported, create a new child container with the `cdmi_job_container_actions` data system metadata set to `ALL` (or include the value `cdmi_job_action_delete`) to indicate to the server that job data objects with delete job actions will be created in this newly created container.

3. Examine the `cdmi_job_container_actions_provided` data system metadata of the newly created container to ensure that `cdmi_job_action_delete` is included in the list.

4. Examine the `cdmi_create_job_dataobject` capability of the newly created container to ensure that job creation is supported.

5. If job data object creation is supported and the desired action is supported, create a new child data object with `cdmi_jobs_action` metadata supporting the `cdmi_job_action_delete` job action.

**EXAMPLE 3:** An example of the job metadata associated with a job container that indicates that only delete action jobs may be created is as follows:

```json
{
    "metadata": {
        "cdmi_job_container_actions": [ "ALL" ],
        "cdmi_job_container_actions_provided": [ "cdmi_job_action_delete" ]
    }
}
```