



IVOA Provenance Table Access Protocol (ProvTAP)

Version 1.0

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Working group

DM

This version

<http://www.ivoa.net/documents/ProvTAP/20180119>

Latest version

<http://www.ivoa.net/documents/ProvTAP>

Previous versions

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Abstract

This document describes the ProvTAP protocol for accessing provenance information according to the IVOA ProvenanceDM standard. It defines how the elements of ProvDM are described in the TAP schema tables and provides guidelines for implementing with TAP 1.1.

Status of This Document

This is an IVOA Working Draft for review by IVOA members and other interested parties. It is a draft document and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use IVOA Working Drafts as reference materials or to cite them as other than “work in progress”.

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1 Introduction

1.1 context

ProvTAP is a TAP service specialization for delivering IVOA Provenance metadata and build up serialisation documents consistently with the IVOA Provenance data model (Riebe and Servillat et al., 2017) As for any TAP

service (Dowler and Rixon et al., 2010), ProvTAP is providing ADQL query responses consisting of a single table each, gathering columns selected from various tables defined in the service’s TAP schema. The default format of the Query Response is VOTable. Other formats (JSON, tsv, etc.) lay also be optionally supported.

The definition of a ProvTAP service is similar to the approach used in the ObsCore specification (Louys and Bonnarel et al., 2011) where ObsCore data model plays the role of underlying model for ObsTAP services. It is also inspired by the multiple table design proposed in the the RegTAP specification (Demleitner and Harrison et al., 2013) with respect to VOResource data model.

Basically, data-model consistency for a TAP service is asserted by the datamodel element in the capability of the service. The relational view of the model is expressed via the table structure in the TAP schema and the definition of each column datatype, ucd, utype attributes in the same schema.

ProvTAP is not the only DAL service able to provide provenance metadata. The ProvDAL (?) specification offers a complementary method based on a search-by-parameters strategy and does not require the server to adopt the TAP architecture. ProvDAL services allow to retrievxes sequences or subgraphs of Provenance metadata associated to a starting entity or activity allowing different combinations.

1.2 Role within the VO architecture

IVOA ProvTAP specification is used to define TAP services with a specific TAP schema expressing view of the IVOA provenance Data Model. It relies on DALI for general DAL definitions. It benefits from existing IVOA notations and standards like UCD, VOUnits, VOTable, VOResource and extensions of the latter such as VODataservice and TAPREgExt.

Fig. 1 shows the dependencies of this document with respect to other existing standards.

2 ProvTAP in action

Here are a few examples of ADQL queries for ProvTAP (values are taken from the test metadata presented in appendix) :

- To retrieve all activity metadata for activies sharing the same activity-Description, by looking for the activities with the same a_description value:

```
SELECT * FROM Activity WHERE  
Activity.a_description = 'hipsgend_mean'
```

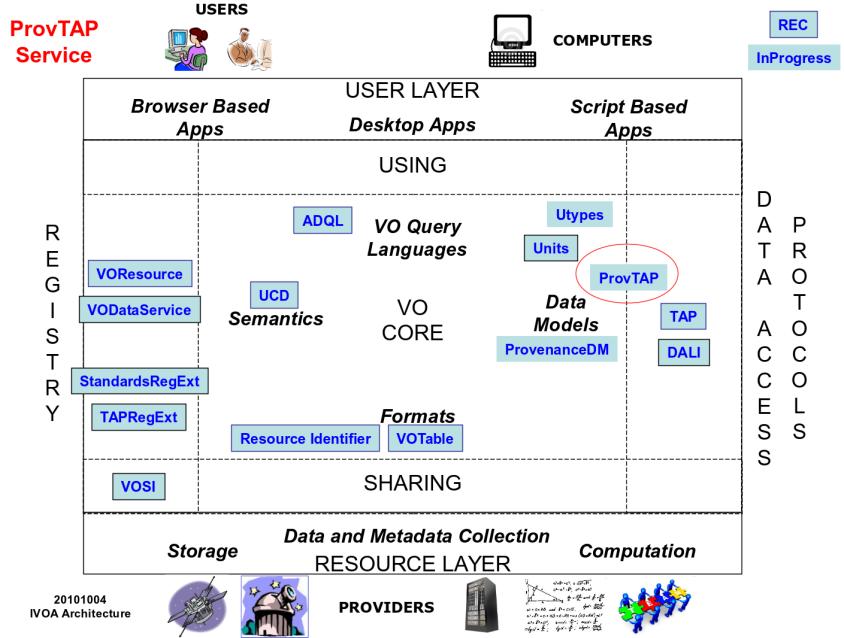


Figure 1: Architecture diagram for the ProvTAP specification. It is based on a view of IVOA Provenance data model and relies on TAP access technology. As such it is fully integrated in the IVOA framework

- To retrieve all activities associated with a specific agent:

```

SELECT WasAssociatedWith.waw_activity_id, Activity.a_name,
       Activity.a_annotation FROM WasAssociatedWith
INNER JOIN Activity ON
WasAssociatedWith.waw_activity_id = Activity.a_id
WHERE WasAssociatedWith.waw_agent_id = 'obspm'

```

- To retrieve all entities identifiers attributed to curator agents:

```

SELECT WasAttributedTo.wat_entity_id FROM WasAttributedTo
WHERE WasAttributedTo.wat_role = 'curator'

```

The result of the first ADQL query is the following.

```

<?xml version="1.0" encoding="UTF-8"?>
<VOTABLE version="1.2" xmlns="http://www.ivoa.net/xml/VOTable/v1.2"
  xmlns:ex="http://www.example.com/provenance"
  xmlns:ivo="http://www.ivoa.net/documents/rer/ivo/"
  xmlns:voprov="http://www.ivoa.net/documents/dm/provdm/voprov/"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.2 http://www.ivoa.net/xml/VOTable-1.2.xsd">
<RESOURCE type="provenance">
  <DESCRIPTION>Provenance VOTable</DESCRIPTION>
  <TABLE >
    <FIELD id="a_ID" name="a_id" ucd="meta.id" utype="voprov:Activity.id" arraysize="*" datatype="char"/>
    <FIELD id="a_nameID" name="a_name" ucd="meta.title" utype="voprov:Activity.name" arraysize="*" datatype="char"/>
    <FIELD id="a_startID" name="a_startTime" ucd="time.start" utype="voprov:Activity.startTime" arraysize="*" datatype="char"/>
  </TABLE >
</RESOURCE>

```

```

<FIELD id="a_endID" name="a_endTime" ucd="time.start" utype="voprov:Activity.endTime" arraysize="*" datatype="char"/>
<FIELD id="a_annotationID" name="a_annotation" ucd="meta.description" utype="voprov:Activity.annotation" arraysize="*" datatype="char"/>
<FIELD id="a_descID" name="a_description" ucd="meta.id" utype="voprov:Activity.description" datatype="char"/>
<DATA>
  <TABLEDATA>
    <TR>
      <TD>HiPSgen1</TD>
      <TD>HiPSgen 1</TD>
      <TD>2017-04-18 17:28:00</TD>
      <TD>2017-04-19 17:29:00</TD>
      <TD>HiPS generation launched on the 18th of April 2017 interpolation method </TD>
      <TD>hipsgend_mean</TD>
    </TR>
  </TABLEDATA>
</DATA>
</TABLE>
<INFO name="QUERY_STATUS" value="OK"/>
</RESOURCE>
</VOTABLE>

```

3 VOSI availability and capabilities

According to the DALI specification for VO services (Dowler and Demleitner et al., 2013), a provenance service implementing ProvTAP must provide a VOSI availability interface as well as a capabilities interface with entries for ProvTAP. The standardIDs for these provenance interfaces are:

`ivo://ivoa.net/std/ProvenanceDM#ProvTAP-1.0`

The capability for a TAP service to support the Provenance DM is expressed by the dataModel element as:

```

<dataModel ivoId="ivo://ivoa.net/std/ProvenanceDM-1.0">
  ProvenanceDM-1.0
</dataModel>

```

For ProvTAP, the VOSI tables interface must also be provided.

4 VOTable serialization for provenance metadata and ProvTAP TAP schema

The table and column definitions available in the TAP schema, including their metadata (`unit`, `ucd`, `utype`, `datatype`, `description`) exactly define the VOTable mapping of the IVOA Provenance data model (see table and column definitions and metadata).

Below is a serialisation format mapping the Provenance data model into VOTable. This format is useful to provide full serialisation of Provenance metadata for an archive or data reduction workflow in VOTable. It can also be used to build the TAP schema of a ProvTAP service.

4.1 Tables in the VOTable serialisation or in the ProvTAP TAP schema

The following table gives the full list of tables necessary to map the IVOA Provenance data model. The contents of the ‘name’ and ‘utype’ columns of this table are normative.

Name	utype	Description
Entity	voprov:Entity	instances of <i>Entity</i> class
EntityDescription	voprov:EntityDescription	instances of <i>EntityDescription</i> class
Activity	voprov:Activity	instances of activity class
ActivityDescription	voprov:ActivityDescription	instances of <i>ActivityDescriptions</i>
Agent	voprov:Agent	instances of <i>Agent</i> class
Parameter	voprov:Parameter	instances of <i>Parameter</i> class
ParameterDescription	voprov:ParameterDescription	instances of <i>ParameterDescription</i>
Used	voprov:Used	instances of <i>Used</i> relationships
UsedDescription	voprov:UsedDescription	instances of <i>UsedDescription</i> relationships
WasGeneratedBy	voprov:WasGeneratedBy	instances of <i>WasGeneratedBy</i> relationships
WasGeneratedByDescription	voprov:WasGeneratedByDescription	instances of <i>WasGeneratedByDescription</i> relationships
WasAssociatedWith	voprov:WasAssociatedWith	instances of <i>WasAssociatedWith</i> relationships
WasAttributedTo	voprov:WasAttributedTo	instances of <i>WasAttributedTo</i> relationships

Table 1: List of tables in the TAP schema

4.2 Detailed table description

Tables 2 to 14 provide full descriptions of the FIELDS of each of the mapping tables. The contents of all these tables’ columns are normative. For convenience, in all these tables an arrow (\rightarrow) indicates columns that contain references (foreign keys) to other tables. The column names are prefixed by a short-cut for the table name in order to ensure unique column names in queries with table joins for ProvTAP.

Name	ucd	utype	datatype
e_id	meta.id	voprov:Entity.id	char
e_name	meta.title	voprov:Entity.name	char
e_type	meta.code.class	voprov:Entity.type	char
e_rights	meta.code.class	voprov:Entity.rights	char
e_annotation	meta.description	voprov:Entity.annotation	char
→ e_hadMember	meta.code.member	voprov:Entity.hadMember	char
→ e_description	meta.id	voprov:Entity.description	char
→ e_usedEntity	meta.id	voprov:Entity.wasDerivedFrom.usedEntity	char

Table 2: Column description for Entity table

Name	ucd	utype	datatype
ed_id	meta.id	voprov:EntityDescription.id	char
ed_name	meta.title	voprov:EntityDescription.name	char
ed_annotation	meta.description	voprov:EntityDescription.annotation	char
ed_category	meta.code.class	voprov:EntityDescription.category	char
ed_doculink	meta.ref.url	voprov:EntityDescription.doculink	char

Table 3: Column description for EntityDescription table

Name	ucd	utype	datatype
a_id	meta.id	voprov:Activity.id	char
a_name	meta.title	voprov:Activity.name	char
a_startTime	time.start	voprov:Activity.startTime	char
a_endTime	time.stop	voprov:Activity.endTime	char
a_annotation	meta.description	voprov:Activity.annotation	char
a_votype	meta.code.class	voprov:Activity.votype	char
→ a_hadStep	meta.code.member	voprov:Activity.hadStep	char
→ a_description	meta.id	voprov:Activity.description	char
→ a_informant	meta.id	voprov:Activity.wasInformedBy.informant	char

Table 4: Column description for Activity table

Name	ucd	utype	datatype
ad_id	meta.id	voprov:ActivityDescription.id	char
ad_name	meta.title	voprov:ActivityDescription.name	char
ad_type	meta.code.class	voprov:ActivityDescription.type	char
ad_subtype	meta.code.class	voprov:ActivityDescription.subtype	char
ad_annotation	meta.description	voprov:ActivityDescription.annotation	char
ad_doculink	meta.ref.url	voprov:ActivityDescription.doculink	char

Table 5: Column description for ActivityDescription table

Name	ucd	utype	datatype
ag_id	meta.id	voprov:Agent.id	char
ag_name	meta.title	voprov:Agent.name	char
ag_type	meta.code.class	voprov:Agent.type	char OPTIONS
ag_address	meta.address	voprov:Agent.address	char
ag_email	meta.email	voprov:Agent.email	char

Table 6: Column description for agent table

Name	ucd	utype	datatype
p_isaParamOf	meta.id	voprov:Parameter.Activity	char
p_id	meta.id	voprov:Parameter.id	char
p_value	stat.value	voprov:Parameter.value	param dependent
→ p_description	meta.id	voprov:Parameter.description	reference to parameter description

Table 7: Column description for Parameter table

Name	ucd	utype	datatype
pd_isaParamOf	meta.id	voprov:ParameterDescription.ActivityDescription	char
pd_id	meta.id	voprov:ParameterDescription.id	char
pd_name	meta.title	voprov:ParameterDescription.name	param dependent
pd_annotation	meta.description	voprov:ParameterDescription.annotation	char
pd_datatype	meta	voprov:ParameterDescription.datatype	char
pd_unit	meta.unit	voprov:ParameterDescription.unit	char
pd_ucd	meta.ucd	voprov:ParameterDescription.ucd	char
pd_utype	meta	voprov:ParameterDescription.utype	char
pd_min	stat.min	voprov:ParameterDescription.min	param dependent
pd_max	stat.max	voprov:ParameterDescription.max	param dependent
pd_options	meta	voprov:ParameterDescription.options	param dependent

Table 8: Column description for ParameterDescription table

Name	ucd	utype	datatype
→ u_entity_id	meta.id	voprov:Used.entity	char
→ u_activity_id	meta.id	voprov:Used.activity	char
→ u_usedDescription_id	meta.id	voprov:Used.usedDescription	char
u_time	time.start	voprov:Used.time	char

Table 9: Column description for Used relationship table

Name	ucd	utype	datatype
→ ud_id	meta.id	voprov:UsedDescription.id	char
→ ud_entityDescription_id	meta.id	voprov:UsedDescription.entityDescription	char
→ ud_activityDescription_id	meta.id	voprov:UsedDescription.activityDescription	char
ud_role	meta.code.class	voprov:UsedDescription.role	char OPTION

Table 10: Column description for UsedDescription relationship table. The value of a role string belongs to a set of possible literal values given for instance using the VOTable OPTION element.

Name	ucd	utype	datatype
→ wgb_entity_id	meta.id	voprov:WasGeneratedBy.entity	char
→ wgb_activity_id	meta.id	voprov:WasGeneratedBy.activity	char
→ wgb_wasGeneratedByDescription_id	meta.id	voprov:WasGeneratedBy.wasGeneratedByDescription	char
wgb_role	meta.code.class	voprov:WasGeneratedBy.role	char OPTION
wgb_time	time.stop	voprov:WasGeneratedBy.time	char

Table 11: Column description for WasGeneratedBy relationship table

Name	ucd	utype	datatype
→ wgbd_id	meta.id	voprov:WasGeneratedByDescription.id	char
→ wgbd_entityDescription_id	meta.id	voprov:WasGeneratedByDescription.entityDescription	char
→ wgbd_activityDescription_id	meta.id	voprov:WasGeneratedByDescription.activityDescription	char
wgbd_role	meta.code.class	voprov:WasGeneratedByDescription.role	char OPTION

Table 12: Column description for WasGeneratedByDescription relationship table

Name	ucd	utype	datatype
→ waw_agent_id	meta.id	voprov:WasAssociatedWith.agent	char
→ waw_activity_id	meta.id	voprov:WasAssociatedWith.activity	char
waw_role	meta.code.class	voprov:WasAssociatedWith.agentRole	char OPTION

Table 13: Column description for WasAssociatedWith relationship table

Name	ucd	utype	datatype
→ wat_entity_id	meta.id	voprov:WasAttributedTo.entity	char
→ wat_agent_id	meta.id	voprov:WasAttributedTo.agent	char
wat_role	meta.code.class	voprov:WasAttributedTo.agentRole	char OPTION

Table 14: Column description for WasAttributedTo relationship table

Appendix A TAP schema in xml

Listing 1: TAP schema in xml

```
<?xml version="1.0" encoding="UTF-8"?>
<vosi:tableset xmlns:vosi="http://www.ivoa.net/xml/VOSITables/v1.0" xmlns=
  <schema>
    <name>provenance</name>
    <description>Provenance schema</description>
    <table type="output">
      <name>Entity</name>
      <description>instances of Entity class</description>
      <column>
        <name>e_id</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta.id</ucd>
        <utype>voprov:Entity.id</utype>
      </column>
      <column>
        <name>e_name</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta.title</ucd>
        <utype>voprov:Entity.name</utype>
      </column>
      <column>
        <name>e_type</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta.code.class</ucd>
        <utype>voprov:Entity.type</utype>
      </column>
      <column>
        <name>e_rights</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta.code.class</ucd>
        <utype>voprov:Entity.rights</utype>
      </column>
      <column>
        <name>e_annotation</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta.description</ucd>
        <utype>voprov:Entity.annotation</utype>
      </column>
      <column>
```

```

<name>e_hadMember</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . code . member</ucd>
<utype>voprov:Entity . hadMember</utype>
</column>
<column>
<name>e_description</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . id</ucd>
<utype>voprov:Entity . description</utype>
</column>
<foreignKey>
<targetTable>EntityDescription</targetTable>
<fkColumn>
<fromColumn>e_description</fromColumn>
<targetColumn>ed_id</targetColumn>
</fkColumn>
</foreignKey>
</table>
<table type="output">
<name>EntityDescription</name>
<description>instances of Entity Description class</description>
<column>
<name>ed_id</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . id</ucd>
<utype>voprov:EntityDescription . id</utype>
</column>
<column>
<name>ed_name</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . title</ucd>
<utype>voprov:EntityDescription . name</utype>
</column>
<column>
<name>ed_doculink</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . ref . url</ucd>
<utype>voprov:EntityDescription . doculink</utype>
</column>
<column>
<name>ed_annotation</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . description</ucd>

```

```

    <utype>voprov:EntityDescription . annotation</utype>
</column>
<column>
    <name>ed_category</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta . code . class</ucd>
    <utype>voprov:EntityDescription . category</utype>
</column>
</table>
<table type="output">
    <name>Activity</name>
    <description>instances of Activity class</description>
    <column>
        <name>a_id</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . id</ucd>
        <utype>voprov:Activity . id</utype>
    </column>
    <column>
        <name>a_name</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . title</ucd>
        <utype>voprov:Activity . name</utype>
    </column>

    <column>
        <name>a_startTime</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>time . start</ucd>
        <utype>voprov:Activity . startTime</utype>
    </column>
    <column>
        <name>a_endTime</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>time . end</ucd>
        <utype>voprov:Activity . endTime</utype>
    </column>
    <column>
        <name>a_annotation</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . description</ucd>
        <utype>voprov:Activity . annotation</utype>
    </column>
    <column>

```

```

<name>a_votype</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . code . class</ucd>
<utype>voprov:Activity . votype</utype>
</column>
<column>
<name>a_hadStep</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . code . member</ucd>
<utype>voprov:Activity . hadStep</utype>
</column>
<column>
<name>a_description</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . id</ucd>
<utype>voprov:Activity . description</utype>
</column>
<foreignKey>
<targetTable>ActivityDescription</targetTable>
<fkColumn>
<fromColumn>a_description</fromColumn>
<targetColumn>ad_id</targetColumn>
</fkColumn>
</foreignKey>
</table>
<table type="output ">
<name>ActivityDescription</name>
<description>instanceof Activity Descriptions </description>
<column>
<name>ad_id</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . id</ucd>
<utype>voprov:ActivityDescription . id</utype>
</column>
<column>
<name>ad_name</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . title</ucd>
<utype>voprov:ActivityDescription . name</utype>
</column>
<column>
<name>ad_doculink</name>
<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . ref . url</ucd>

```

```

    <utype>voprov:ActivityDescription . doculink</utype>
</column>
<column>
    <name>ad_annotation</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta . description</ucd>
    <utype>voprov:ActivityDescription . annotation</utype>
</column>
<column>
    <name>ad_type</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta . code . class</ucd>
    <utype>voprov:ActivityDescription . type</utype>
</column>
<column>
    <name>ad_subtype</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta . code . class</ucd>
    <utype>voprov:ActivityDescription . subtype</utype>
</column>
</table>
<table type="output">
    <name>Agent</name>
    <description>instance of Agent class </description>
    <column>
        <name>ag_id</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . id</ucd>
        <utype>voprov:Agent . id</utype>
    </column>
    <column>
        <name>ag_name</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . title</ucd>
        <utype>voprov:Agent . name</utype>
    </column>
    <column>
        <name>ag_type</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . code . class</ucd>
        <utype>voprov:Agent . type</utype>
    </column>
    <column>
        <name>ag_address</name>

```

```

<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta . address</ucd>
<utype>voprov:Agent . address</utype>
</column>
<column>
  <name>ad_email</name>
  <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
  <ucd>meta . email</ucd>
  <utype>voprov:Agent . email</utype>
</column>
</table>
<table type="output ">
  <name>Parameter</name>
  <description>instance of Parameter class </description>
  <column>
    <name>p_isaParamOf</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta . id</ucd>
    <utype>voprov:Parameter . Activity</utype>
  </column>
  <column>
    <name>p_id</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta . id</ucd>
    <utype>voprov:Parameter . id</utype>
  </column>
  <column>
    <name>p_value</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>stat . value</ucd>
    <utype>voprov:Parameter . value</utype>
  </column>
  <column>
    <name>p_description</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta . id</ucd>
    <utype>voprov:Parameter . description</utype>
  </column>
  <foreignKey>
    <targetTable>ParameterDescription</targetTable>
    <fkColumn>
      <fromColumn>p_description</fromColumn>
      <targetColumn>pd_id</targetColumn>
    </fkColumn>

```

```

    </foreignKey>
    <foreignKey>
        <targetTable>Activity</targetTable>
        <fkColumn>
            <fromColumn>p_isaParamOf</fromColumn>
            <targetColumn>a_id</targetColumn>
        </fkColumn>
    </foreignKey>
</table>
<table type="output">
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    <description>instance of Parameter Descriptions </description>
    <column>
        <name>pd_isaParamOf</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . id</ucd>
        <utype>voprov:ParameterDescription . ActivityDescription</utype>
    </column>
    <column>
        <name>pd_id</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . id</ucd>
        <utype>voprov:ParameterDescription . id</utype>
    </column>
    <column>
        <name>pd_name</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . title</ucd>
        <utype>voprov:ParameterDescription . name</utype>
    </column>
    <column>
        <name>pd_annotation</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . description</ucd>
        <utype>voprov:ParameterDescription . annotation</utype>
    </column>
    <column>
        <name>pd_datatype</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta</ucd>
        <utype>voprov:ParameterDescription . datatype</utype>
    </column>
    <column>
        <name>pd_unit</name>

```

```

<dataType xsi:type="vod:TAPType">VARCHAR</dataType>
<ucd>meta.unit</ucd>
<utype>vprov:ParameterDescription.unit</utype>
</column>
<column>
  <name>pd_ucd</name>
  <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
  <ucd>meta.ucd</ucd>
  <utype>vprov:ParameterDescription.ucd</utype>
</column>
<column>
  <name>pd_utype</name>
  <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
  <ucd>meta</ucd>
  <utype>vprov:ParameterDescription.utype</utype>
</column>
<column>
  <name>pd_utype</name>
  <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
  <ucd>meta</ucd>
  <utype>vprov:ParameterDescription.utype</utype>
</column>
<column>
  <name>pd_min</name>
  <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
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  <utype>vprov:ParameterDescription.min</utype>
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<column>
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  <ucd>stat.max</ucd>
  <utype>vprov:ParameterDescription.max</utype>
</column>
<column>
  <name>pd_options</name>
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  <ucd>meta</ucd>
  <utype>vprov:ParameterDescription.options</utype>
</column>
<foreignKey>
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    <fromColumn>pd_isaParamOf</fromColumn>

```

```

        <targetColumn>ad_id</targetColumn>
    </fkColumn>
</foreignKey>
</table>
<table type="output">
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    <column>
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        <utype>voprov:Used . entity</utype>
    </column>
    <column>
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        <ucd>meta . id</ucd>
        <utype>voprov:Used . activity</utype>
    </column>

    <column>
        <name>u_usedDescription_id</name>
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        <ucd>meta . id</ucd>
        <utype>voprov:Used . usedDescription</utype>
    </column>
    <column>
        <name>u_time</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>time . start</ucd>
        <utype>voprov:Used . time</utype>
    </column>
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        <fkColumn>
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            <targetColumn>ud_usedDescription_id</targetColumn>
        </fkColumn>
    </foreignKey>
    <foreignKey>
        <targetTable>Entity</targetTable>
        <fkColumn>
            <fromColumn>u_entity_id</fromColumn>
            <targetColumn>e_id</targetColumn>

```

```

        </fkColumn>
    </foreignKey>
    <foreignKey>
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        </fkColumn>
    </foreignKey>
</table>
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    <description>instance of Used Descriptions</description>
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        <ucd>meta . id</ucd>
        <utype>voprov:UsedDescription . id</utype>
    </column>
    <column>
        <name>ud_entityDescription_id</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . id</ucd>
        <utype>voprov:UsedDescription . entityDescription</utype>
    </column>
    <column>
        <name>ud_activityDescription_id</name>
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        <utype>voprov:UsedDescription . activityDescription</utype>
    </column>
    <column>
        <name>ud_role</name>
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        </fkColumn>
    </foreignKey>

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```

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    <utype>vprov:WasGeneratedBy . entity</utype>
  </column>
  <column>
    <name>wgb_activity_id</name>
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    <utype>vprov:WasGeneratedBy . activity</utype>
  </column>
  <column>
    <name>wgb_wasGeneratedByDescription_id</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta . id</ucd>
    <utype>vprov:WasGeneratedBy . wasGeneratedByDescription</utype>
  </column>
  <column>
    <name>wgb_time</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>time . start</ucd>
    <utype>vprov:wasGeneratedBy . time</utype>
  </column>
  <foreignKey>
    <targetTable>WasGeneratedByDescription</targetTable>
    <fkColumn>
      <fromColumn>wgb_wasGeneratedByDescription_id</fromColumn>
      <targetColumn>wgbd_id</targetColumn>
    </fkColumn>
  </foreignKey>
  <foreignKey>
    <targetTable>Entity</targetTable>

```

```

<fkColumn>
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</fkColumn>
</foreignKey>
<foreignKey>
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    <fkColumn>
        <fromColumn>wgb_Activity_id</fromColumn>
        <targetColumn>a_id</targetColumn>
    </fkColumn>
</foreignKey>
</table>
<table type="output">
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    <description>instance of WasGeneratedBy Descriptions</description>
    <column>
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        <ucd>meta . id</ucd>
        <utype>vprov:WasGeneratedByDescription . id</utype>
    </column>
    <column>
        <name>wgbd_entityDescription_id</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . id</ucd>
        <utype>vprov:WasGeneratedByDescription . entityDescription</utype>
    </column>
    <column>
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        <ucd>meta . id</ucd>
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    </column>
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        <name>wgbd_role</name>
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        <ucd>meta . code . class</ucd>
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    </column>
    <targetTable>EntityDescription</targetTable>
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```

```

        </fkColumn>
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    <foreignKey>
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</table>
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        <utype>voprov:WasAssociatedWith . agent</utype>
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    <column>
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        <utype>voprov:WasAssociatedWith . activity</utype>
    </column>
    <column>
        <name>waw_role</name>
        <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
        <ucd>meta . code . class</ucd>
        <utype>voprov:WasAssociatedWith . agentRole</utype>
    </column>
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    <fkColumn>
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        <targetColumn>ag_id</targetColumn>
    </fkColumn>
    <foreignKey>
        <targetTable>Activity</targetTable>
        <fkColumn>
            <fromColumn>waw_activity_id</fromColumn>
            <targetColumn>a_id</targetColumn>
        </fkColumn>
    </foreignKey>

```

```

</table>
<table type="output">
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    <utype>voprov:WasAttributedTo.entity</utype>
  </column>
  <column>
    <name>wat_agent_id</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta.id</ucd>
    <utype>voprov:WasAttributedTo.Agent</utype>
  </column>
  <column>
    <name>wat_role</name>
    <dataType xsi:type="vod:TAPType">VARCHAR</dataType>
    <ucd>meta.code.class</ucd>
    <utype>voprov:WasAttributedTo.agentRole</utype>
  </column>
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  <fkColumn>
    <fromColumn>wat_entity_id</fromColumn>
    <targetColumn>e_id</targetColumn>
  </fkColumn>
  </foreignKey>
  <foreignKey>
    <targetTable>Entity</targetTable>
    <fkColumn>
      <fromColumn>wat_activity_id</fromColumn>
      <targetColumn>a_id</targetColumn>
    </fkColumn>
  </foreignKey>
</table>
</schema>
</vos:tableset>

```

Appendix B TAP service content exemple. Database dump in VOTable.

Following exemple gathers information on data collections used or gathered by CDS in the context of Aladin. It starts from Schmidt plate collections and

goes up to HiPS datasets and collections. These metadata are organized below into a set of related VOTables.

Listing 2: TAP schema in xml

```

<?xml version="1.0" encoding="utf-8"?>
<!-- Produced with astropy.io.votable version 0.3 http://www.astropy.org/
<VOTABLE version="1.2" xmlns="http://www.ivoa.net/xml/VOTable/v1.2" xmlns=
    <RESOURCE type="input_data">
        <!-- compatible DM 2018-Jan- 29 -->
<TABLE name="Activity">
    <FIELD ID="a_id" arraysize="*" datatype="char" name="a_id"
        ucd="meta.id" utype="voprov:Activity.id"/>
    <FIELD ID="a_name_ID" arraysize="*" datatype="char" name="a_name"
        ucd="meta.title" utype="voprov:Activity.name"/>
    <FIELD ID="a_start_ID" arraysize="*" datatype="char" name="a_startTime"
        ucd="time.start" utype="voprov:Activity.startTime"/>
    <FIELD ID="a_end_ID" arraysize="*" datatype="char" name="a_endTime"
        ucd="time.end" utype="voprov:Activity.endTime"/>
    <FIELD ID="a_annotation_ID" arraysize="*" datatype="unicodeChar"
        name="a_annotation" ucd="meta.description" utype="voprov:Activity.annotation"/>
    <FIELD ID="a_desc_ID" arraysize="*" datatype="char" name="a_description"
        ucd="meta.id" utype="voprov:Activity.description"/>
<DATA>
    <TABLEDATA>
        <!-- color composition -->
        <TR>
            <TD>AlaRGB1</TD>
            <TD>Aladin RGB 1</TD>
            <TD>2017-04-18T17:28:00</TD>
            <TD>2017-04-19T17:29:00</TD>
            <TD>Aladin RGB image generation for NGC 6946</TD>
            <TD>AlaRGB</TD>
        </TR>
        <TR>
            <TD>AlaRGB2</TD>
            <TD>Aladin RGB 2</TD>
            <TD>2017-04-18T17:34:00</TD>
            <TD>2017-04-19T17:35:00</TD>
            <TD>Aladin RGB image generation for Messier 101</TD>
            <TD>AlaRGB</TD>
        </TR>
        <TR>
            <TD>AlaRGB3</TD>

```

```

<TD>Aladin RGB 3</TD>
<TD>2017-04-18 T17:41:00</TD>
<TD>2017-04-19 T17:42:00</TD>
<TD>Aladin RGB image generation for Messier 33</TD>
<TD>AlaRGB</TD>
</TR>
<TR>
<TD>AlaRGB4</TD>
<TD>Aladin RGB 4</TD>
<TD>2017-04-18 T17:45:00</TD>
<TD>2017-04-19 T17:46:00</TD>
<TD>Aladin RGB image generation for Messier 51</TD>
<TD>AlaRGB</TD>
</TR>
<TR>
<TD>AlaRGB5</TD>
<TD>Aladin RGB 5</TD>
<TD>2017-04-18 T17:47:00</TD>
<TD>2017-04-19 T17:48:00</TD>
<TD>Aladin RGB image generation for Messier 81</TD>
<TD>AlaRGB</TD>
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<TR>
<TD>AlaRGB6</TD>
<TD>Aladin RGB 6</TD>
<TD>2017-04-18 T17:50:00</TD>
<TD>2017-04-19 T17:51:00</TD>
<TD>Aladin RGB image generation for Messier 83</TD>
<TD>AlaRGB</TD>
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<TR>
<TD>AlaRGB7</TD>
<TD>Aladin RGB 7</TD>
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<TD/>
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```

```

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</TR>
<!-- numerisation -->
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</TR>
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NGC 6946

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Appendix C Changes from Previous Versions

mireille: changed stopTime everywhere in endTime and ucd “time.stop” in “time.end” to ensure compatibility with provDM tables.

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