

XCEDE 2.0 - A Manual

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Introduction

This is a manual for version 2.0 of XCEDE (XML-based Clinical and Experimental Data Exchange). XCEDE 2.0 is an extensible schema designed to enable the transfer and storage of several types of scientific data and metadata including (but not limited to) clinical, demographic, behavioral, physiological and image data. The target audience for this manual is anyone who is interested in using or learning more about XCEDE 2.0. This manual will serve as both a tutorial and as a reference.

Though the schema was designed in the context of neuroscientific projects, the structure of the schema is quite generic and can be applied as is to a wide variety of scientific disciplines.

1. Manual structure

This manual has two parts. Part I describes the various components of XCEDE 2.0 and describes the specification in some detail. Part II is a more practical guide to the use of XCEDE 2.0, providing guidance to those users who wish to extend the schema to represent project-specific metadata, or integrating XCEDE 2.0 into software applications and services.

2. Development

XCEDE 2.0 development started as an effort to "harmonize" the uses of XML within the BIRN (Biomedical Informatics Research Network) testbeds and collaborators within the neuroscientific community. The feedback from these discussion sessions led to an initial prototype (based on XCEDE 1.0) of a next-generation schema. Over the course of four months of daily teleconferences, the first public release of XCEDE 2.0 took form.

XCEDE 2.0 has its origins in various XML schemas developed for collaborative neuroinformatics projects, including:

fMRI Data Center schema	a general scientific metadata storage framework.
XNAT (Extensible Neuroimaging Toolkit)	database and web service designed to facilitate management and exploration of neuroimaging and related data.
BIAC XML Header schema	provides a format-agnostic interface to image data and is the basis for the <i>binary data resource</i> in XCEDE 2.0.
BIRN Data Provenance schema	records the history of processing steps.
XCEDE (1.0) SPM Toolbox	provides a general framework (and MATLAB interface) for storage and retrieval of thresholded statistical parametric maps and associated anatomical labels.

The primary developers of XCEDE 2.0 are (in alphabetical order): Syam Gadde (Duke University), Jeff Grethe (University of California, San Diego), Dave Keator (University of California, Irvine), and Dan Marcus (Washington University, St. Louis), all of whom have received support for this project through various BIRN testbeds.

3. For More Information

XXX Contacts XXX

The latest schema and related information can be found on the project's web page at <http://www.xcede.org/>.

Part I. XCEDE 2.0 Core Specification

This section of the XCEDE 2.0 manual focuses on the high-level structure and major components of the XCEDE 2.0 Core schema. Each chapter contains a description of the component and provides examples of usage. The examples in this section are largely drawn from neuroscientific metadata, as this data served as the driving force behind development. However, these examples are by no means comprehensive; the schema was designed to be generally applicable (and extensible) to many types of scientific data, and this manual by necessity focuses on only a few.

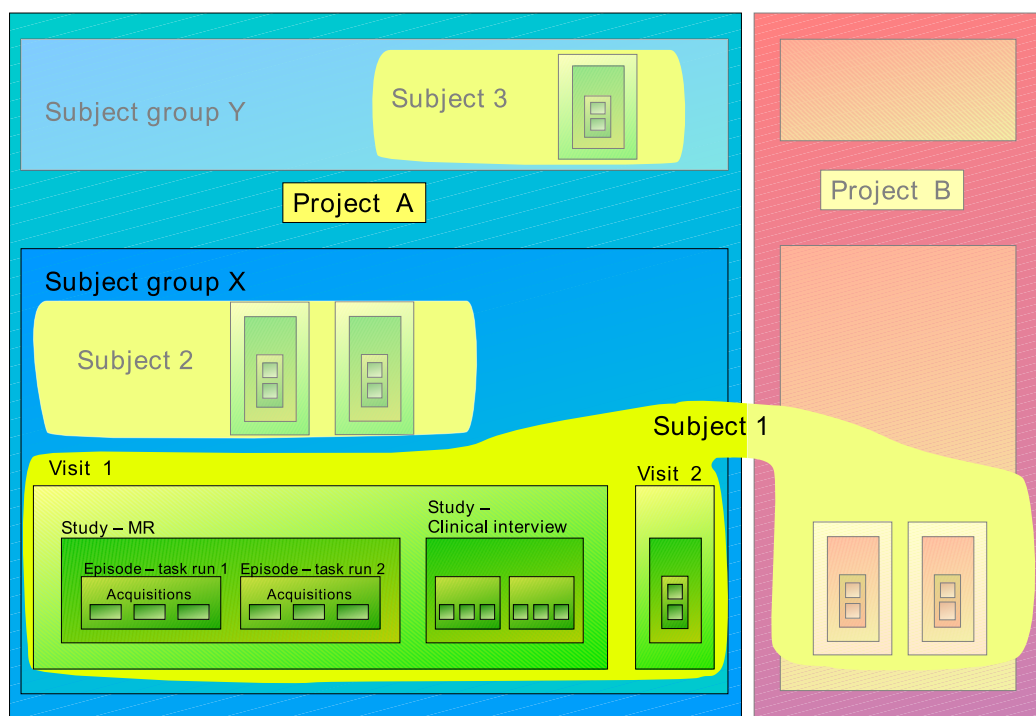
Chapter 1. XCEDE Structure and Conventions

Chapter 2. Experiment Hierarchy

2.1. Overview

As illustrated in Figure 2.1, the XCEDE experiment hierarchy consists of several *levels* representing divisions of experiment data at various granularities. Elements at each level contain level-specific "info" elements, whose schema types may be derived to store experiment-specific or data modality-specific metadata. The linking mechanism between levels is flexible enough to support the omission of levels if the schema user finds them unnecessary.

Figure 2.1. XCEDE hierarchy



2.1.1. Hierarchy Levels

In the typical intended usage, a *project* is the top-level division of experiment data, and represents a research project which collects and analyzes data from one or more *subjects* which are divided (within the project) into *subject groups*. A subject may be a member of multiple research projects, and it is the subject group that maintains and distinguishes the mappings between subjects and research projects.

A *visit* may represent a subject's appearance at an experiment "site" (for collaborative projects, this could be the institution or lab at which the data is being collected or analyzed). A visit, may be further subdivided into one or more *studies*, each of would consist of one or more data collection *episodes*.

Visit and study are more or less arbitrary divisions of the data that exist for convenience, and do not in themselves have any inherent meaning as far as the schema is concerned. However, an episode is intended to represent a unit of data collection over a given time interval, and should contain one or more data *acquisitions*, which should be understood to occur simultaneously over the duration of the episode. So, for example, an episode in an fMRI study may encapsulate the acquisition of a time-series of volume images from an MR scanner, as well as other acquisitions of behavioral or physiological data; all these (simultaneous) acquisitions would be stored as part of the same episode.

It would be natural to represent the experiment hierarchy as described as a traditional XML hierarchy, where higher-level elements encapsulate lower-level elements as child elements. However, in XCEDE, all level elements (`<project>`, `<visit>`, etc.) are stored as children of the root `<XCEDE>` element. Links between levels are implicit in the level IDs assigned to each element and propagated to elements in lower levels. One advantage of this approach is to allow users of the schema to omit levels merely by omitting the unnecessary elements and IDs/links. Applications are also easier to write because all major elements are stored in the same place (under the XCEDE root element).

2.1.2. IDs and Linking

Any level element can be the target of a link from another element. In addition, most level elements are implicitly linked to "ancestor" level elements. Both these types of links are created by specifying one or more *level IDs* that together uniquely describe a target level element.

Every level element has a set of these level IDs, composed of the element's own ID attribute, plus its "ancestor" ID attributes, indicating which higher-level elements have this element in their scope. For example, the `<visit>` element contains `subjectGroupID`, `subjectID`, and `projectID` attributes.

For example, a link to a visit element may specify `visitID`, `subjectID`, `subjectGroupID`, and `projectID` attributes, and a `level` attribute with the value `visit`, indicating that this link is to a visit element. An application resolving this link will search for a visit element whose attributes match those specified in the link (the `visitID` attribute is matched against the `ID` attribute in the visit element). Level ID attributes not specified in the link should match any value, but a link must specify enough of these IDs match at most one level element.

The elements that can link to any level element are `<catalog>`, `<resource>`, and `<data>` (children of the `<XCEDE>` root element), `<inputRef>` and `<outputRef>` (children of the `<analysis>` element). Level elements (except for `<project>` and `<subject>`, which are at the top of the experiment hierarchy) can be implicitly linked to ancestor elements using the attributes provided.

2.2. Examples

2.2.1. Metadata hierarchy

The metadata hierarchy illustrated in Figure 2.1 can be represented in XCEDE as shown in Figure 2.2 (only those elements/attributes relevant to linking are shown; the actual metadata contents of the elements are omitted for space).

Figure 2.2. Metadata hierarchy instance

```
<XCEDE xmlns="http://www.xcede.org/xcede-2">
  <project ID="A">
    <projectInfo>
      <subjectGroupList>
        <subjectGroup ID="X">
          <subjectID>1</subjectID>
          <subjectID>2</subjectID>
        </subjectGroup>
      </subjectGroupList>
    </projectInfo>
  </project>
  <project ID="B">
    <projectInfo>
      <subjectGroupList>
        <subjectGroup ID="Z">
          <subjectID>3</subjectID>
        </subjectGroup>
      </subjectGroupList>
    </projectInfo>
  </project>
  <subject ID="1" />
  <subject ID="2" />
  <subject ID="3" />
  <visit ID="1"
    projectID="A" subjectID="1" subjectGroupID="X" />
  <study ID="MR scan"
    projectID="A" subjectID="1" subjectGroupID="X" visitID="1" />
  <episode ID="task run 1"
    projectID="A" subjectID="1" subjectGroupID="X" visitID="1" studyID="MR" />
  <acquisition ID="MR image"
    projectID="A" subjectID="1" subjectGroupID="X" visitID="1" studyID="MR"
    episodeID="task run 1" />
  <acquisition ID="behavioral data"
    projectID="A" subjectID="1" subjectGroupID="X" visitID="1" studyID="MR"
    episodeID="task run 1" />
  <acquisition ID="heart rate"
    projectID="A" subjectID="1" subjectGroupID="X" visitID="1" studyID="MR"
    episodeID="task run 1" />
  <study ID="Clinical interview"
    projectID="A" subjectID="1" subjectGroupID="X" visitID="2" />
  <!-- ... etc. ... -->
</XCEDE>
```

Chapter 3. Binary Data Resources

3.1. Overview

The XCEDE *Binary Data Resource* component is used to provide a generic interface to a binary data stream stored in one or more external files. Any of the binary data resource types described in this chapter can be used anywhere an `abstract_resource_t` is called for (with the appropriate `xsi:type` attribute); in the current XCEDE schema, these locations are the top-level `<resource>` element and the `<dataResource>` child element of `<acquisition>`.

XCEDE provides multiple layers of derived types to store more specialized information about the binary data. The base type and each of the derived types are described in turn.

abstract_resource_t. The abstract base type `abstract_resource_t` provides a few elements and attributes that are especially important for binary data resources. In particular, the `<uri>` element and its `offset` and `size` attributes point to a “chunk” of data stored in an external file. A series of `<uri>` elements define a stream of data that may be described in greater detail by the data types described below.

binaryDataResource_t. This type derives from `abstract_resource_t` and allows an application to interpret the data stream as a sequence of data items with a given data type (`<elementType>`) and byte order (`<byteOrder>`).

dimensionedBinaryDataResource_t. The data stream, until now, could only be interpreted as a one-dimensional sequence. This type provides `<dimension>` elements that allow the data stream to be interpreted as a multi-dimensional array of data items. Each dimension has a `<size>` and a `<label>`, as well as the ability to discard subsets of the data in the data stream (using the `outputSelect` attribute).

mappedBinaryDataResource_t. This type places the multi-dimensional array of data items represented by `dimensionedBinaryDataResource_t` into an arbitrary coordinate system.

3.2. Examples

Several examples of binary data are presented here, each showing the use of one of the different binary data types described in this chapter.

3.2.1. Basic data stream

The basic binary data resource type describes a sequence of data items. For example, consider a data file (`random_data_file.bin`) containing 2048 random 32-bit floating point numbers, stored in little-endian (least-significant-byte first) order. The `<dataResource>` describing this data is shown in Figure 3.1.

Figure 3.1. Simple `binaryDataResource_t` example

```
<dataResource xsi:type="binaryDataResource_t">
  <uri offset="0" size="8192">random_data_file.bin</uri>
  <elementType>float32</elementType>
  <byteOrder>lsbfirst</byteOrder>
</dataResource>
```

Note the `xsi:type` specifying that this `<dataResource>` element is of type `binaryDataResource_t`. (The `xsi:` prefix should have already been declared previously in the XML file using something similar to `xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"`)

The `<elementType>` element is restricted to one of several pre-defined strings (see the schema for details). The `<byteOrder>` element must be `lsbfirst` for little-endian data or `msbfirst` for big-endian data.

If the `<compression>` element is specified, it specifies that the file(s) pointed to by the `<uri>` elements are compressed. The content of the element should specify which type of compression (the only compression method specifically recognized by this specification is `gzip`). The size and offset attributes in the `<uri>` element always refer to the *uncompressed* data. An example of this is shown in Figure 3.2.

Figure 3.2. `binaryDataResource_t` with compression

```
<dataResource xsi:type="binaryDataResource_t">
  <uri offset="0" size="8192">random_data_file.bin.gz</uri>
  <elementType>float32</elementType>
  <byteOrder>lsbfirst</byteOrder>
  <compression>gzip</compression>
</dataResource>
```

As a special case, if the application does not find the file pointed to by a URI, and the `<compression>` element is *not* present, it may search for the same file with an appended `.gz` suffix, and if it exists, treat it as implicitly `gzip`-compressed data. Figure 3.3 shows how the same data in Figure 3.2 could be expressed using this alternative method. Pointing to the uncompressed version of the file (even when only the compressed version exists) allows the user to decompress or compress the data file at will, without affecting the ability of the application to read the data using the same `binaryDataResource_t`. Note that the `<uri>` and `<compression>` elements must be internally consistent. It would be an error to reference the uncompressed file `random_data_file.bin` and yet say that it was compressed using `<compression>gzip</compression>`. Likewise, explicit references to the compressed file (especially files that do not have the `.gz` suffix) must specify the compression method explicitly using the `compression` element.

Figure 3.3. `binaryDataResource_t` with implicit compression

```
<dataResource xsi:type="binaryDataResource_t">
  <uri offset="0" size="8192">random_data_file.bin</uri>
  <elementType>float32</elementType>
  <byteOrder>lsbfirst</byteOrder>
</dataResource>
```

3.2.2. Dimensioned data

Consider a camera that acquires an image using a 256x256 matrix of big-endian 32-bit signed integer voxels. This data has two spatial dimensions, which, by convention, we label `x`, and `y` (and `z` if a third spatial dimension is needed, and `t` if there is a time dimension). Figure 3.4 shows how this data might be represented.

Figure 3.4. `dimensionedBinaryDataResource_t` example

```
<dataResource xsi:type="dimensionedBinaryDataResource_t">
  <uri offset="0" size="262144">rawdata.img</uri>
  <elementType>int32</elementType>
  <byteOrder>msbfirst</byteOrder>
  <dimension label="x">
    <size>256</size>
  </dimension>
  <dimension label="y">
    <size>256</size>
  </dimension>
</dataResource>
```

Dimensions are ordered from fastest-moving to slowest-moving. So in the above example, the x dimension index changes on each consecutive data item, but the y dimension changes every 256 elements.

3.2.3. Mapped data

A “mapped” binary data resource is a (perhaps multidimensional) array of values, the matrix indices of which can be converted into a location in a given coordinate system. The location of the bounding box of the data in this space is given by specifying a location (in target-space coordinates) for the first data item, and two things for each dimension: a unit-length direction vector (in the target-space coordinate system) and the spacing between successive data items in that dimension. The transformation matrix for a three-dimensional coordinate system has the form shown in Figure 3.5. This transformation matrix converts from matrix indices (x, y, z) to a coordinate location (a, b, c) . Figure 3.6 shows how the components of a transformation of MR image data into scanner RAS (Right/Anterior/Superior) coordinates are represented in a `mappedBinaryDataResource_t`. The unit vectors for each dimension are $(X_A \ X_B \ X_C) = (1 \ 0 \ 0)$, $(Y_A \ Y_B \ Y_C) = (0 \ 1 \ 0)$, and $(Z_A \ Z_B \ Z_C) = (0 \ 0 \ 1)$, and are placed in the `<direction>` elements in each `<dimension>` element. The spacing values $(S_X \ S_Y \ S_Z) = (3.75\text{mm} \ 3.75\text{mm} \ 4\text{mm})$ are put in the `<spacing>` element in each `<dimension>`. The coordinates of the first voxel in the data are given by $(O_A \ O_B \ O_C) = (-120 \ -120 \ -52)$.

Figure 3.5. Transformation matrix

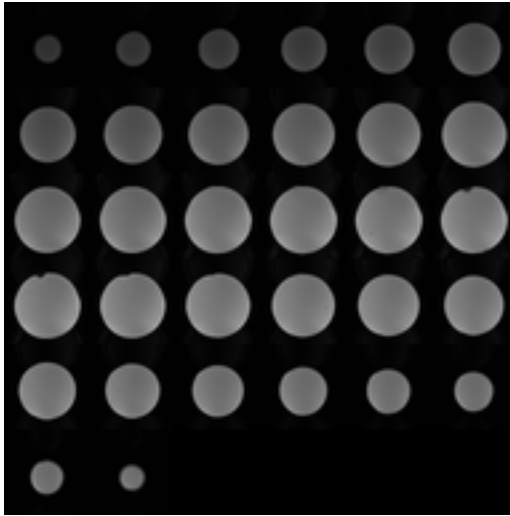
$$\begin{pmatrix} X_A & Y_A & Z_A & O_A \\ X_B & Y_B & Z_B & O_B \\ X_C & Y_C & Z_C & O_C \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} S_X & 0 & 0 & 0 \\ 0 & S_Y & 0 & 0 \\ 0 & 0 & S_Z & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} i \\ j \\ k \\ 1 \end{pmatrix} = \begin{pmatrix} a \\ b \\ c \\ 1 \end{pmatrix}$$

Figure 3.6. mappedBinaryDataResource_t example

```
<dataResource xsi:type="mappedBinaryDataResource_t">
  <uri offset="0" size="442368">V0001.img</uri>
  <uri offset="0" size="442368">V0002.img</uri>
  <uri offset="0" size="442368">V0003.img</uri>
  <uri offset="0" size="442368">V0004.img</uri>
  <uri offset="0" size="442368">V0005.img</uri>
  <!-- ... 135 more <uri> elements omitted for space ... -->
  <elementType>int32</elementType>
  <byteOrder>msbfirst</byteOrder>
  <dimension label="x">
    <size>64</size>
    <spacing>3.75</spacing>
    <gap>0</gap>
    <direction>1 0 0</direction>
    <units>mm</units>
  </dimension>
  <dimension label="y">
    <size>64</size>
    <spacing>3.75</spacing>
    <gap>0</gap>
    <direction>0 1 0</direction>
    <units>mm</units>
  </dimension>
  <dimension label="z">
    <size>27</size>
    <spacing>4</spacing>
    <gap>1</gap>
    <direction>0 0 1</direction>
    <units>mm</units>
  </dimension>
  <dimension label="t">
    <size>140</size>
    <spacing>2</spacing>
    <gap>0</gap>
    <datapoints>0 2 4 6 8</datapoints>
    <units>sec</units>
  </dimension>
  <originCoords>-120 -120 -52</originCoords>
</dataResource>
```

3.2.4. Advanced topic: split dimensions and outputSelect

A more complicated example is given by data generated by a Siemens MR scanner. In this case, the data represents a three-dimensional 64x64x32 image, stored in DICOM format. However, because the earlier versions of the DICOM format did not support three-dimensional data in one file, Siemens came upon the clever idea to “tile” the 32 two-dimensional slices across an NxN two-dimensional grid (Figure 3.7).

Figure 3.7. A “tiled” image

Applications may naturally want to express this data as a three-dimensional block, with columns, rows, and slices. In a conventionally-stored three-dimensional $X \times Y \times Z$ image, the first X voxels compose the first row in the first slice, and then the next X voxels are the second row in the first slice; likewise the first $X \times Y$ voxels are the first slice, and the next $X \times Y$ voxels are the second slice, and so on. However, in the “tiled” image, though the first X voxels are again the first row in the first slice, the next X voxels are the first row in the second slice! At first it would seem that the dimension order has merely been switched, and specifying the labels of the dimensions as x , z , and y would fix things. However, we only hit six slices' first rows before hitting going to the second row of the same six slices. Only after going through all the rows in this fashion in the first six slices do we go on to the next six slices.

The end result is that the dimension that we are calling the z dimension has been split in two. The two components of the z dimension are interleaved with the x and y dimensions like so: x , z_1 , y , z_2 . The two components of the z dimension are distinguished with the `splitRank` attribute, as shown in Figure 3.8.

Figure 3.8. Split dimension example

```
<dataResource xsi:type="binaryDataResource_t">
  <uri offset="9240" size="589824">img0001.dcm</uri>
  <elementType>uint32</elementType>
  <byteOrder>lsbfirst</byteOrder>
  <dimension label="x">
    <size>64</size>
  </dimension>
  <dimension label="z" splitRank="1">
    <size>6</size>
  </dimension>
  <dimension label="y">
    <size>64</size>
  </dimension>
  <dimension label="z" splitRank="2">
    <size>6</size>
  </dimension>
</dataResource>
```

Applications should read this data as if it were four dimensions, and then permute the data to bring the two z dimensions together (in the order specified by `splitRank`) in the position of the highest-ranked split dimension, and the two dimensions can then be merged into one. The size of the new z dimension is the product of the sizes of the component split dimensions, so $6 * 6 = 36$.

You may recall that the original data was acquired as a 64x64x32 volume, but the NxN tiling representation requires that the number of tiles be the square of an integer N. One more mechanism has been added to the `<dimension>` element to accommodate the presence of data that should be disregarded: the `outputSelect` attribute (see Figure 3.9).

Figure 3.9. `outputSelect` example

```
<dataResource xsi:type="binaryDataResource_t">
  <uri offset="0" size="589824">img0001.dcm</uri>
  <elementType>uint32</elementType>
  <byteOrder>lsbfirst</byteOrder>
  <dimension label="x">
    <size>64</size>
  </dimension>
  <dimension label="z" splitRank="1">
    <size>6</size>
  </dimension>
  <dimension label="y">
    <size>64</size>
  </dimension>
  <dimension label="z" splitRank="2" outputSelect="0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31">
    <size>6</size>
  </dimension>
</dataResource>
```

The `outputSelect` attribute specifies a list of indices along the given dimension (or combined dimension if it occurs on the highest-ranked component of a split dimension) that should be regarded as valid data. Data in the other indices should be ignored.

Chapter 4. Catalogs

4.1. Overview

Catalogs in XCEDE 2 are containers of related resources, resource references, and data references. They are recursive in that catalogs can contain a list of catalogs and catalog references.

Catalogs are represented by the `catalog_t` complex type, derived from `abstract_tagged_entity_t`. The catalog child element of the root XCEDE element is of type `catalog_t`. The resources included in the catalog can be pointed to from by resource references in a number of places in XCEDE, including `analysis_t` and `acquisition_t`.

Catalogs are useful in a number of contexts. A catalog could be created, for example, to represent all of the acquisition resources associated with an episode. These catalogs could be contained within a parent catalog that represents each of the episodes in an MR study. Catalogs could also be used to represent the various resources generated as part of an analysis or uploaded and tagged by users.

A benefit of using catalogs, as opposed to linking resources directly in analysis and acquisition elements, is that the catalogs can be sent to client applications that choose not to support the full XCEDE specification.

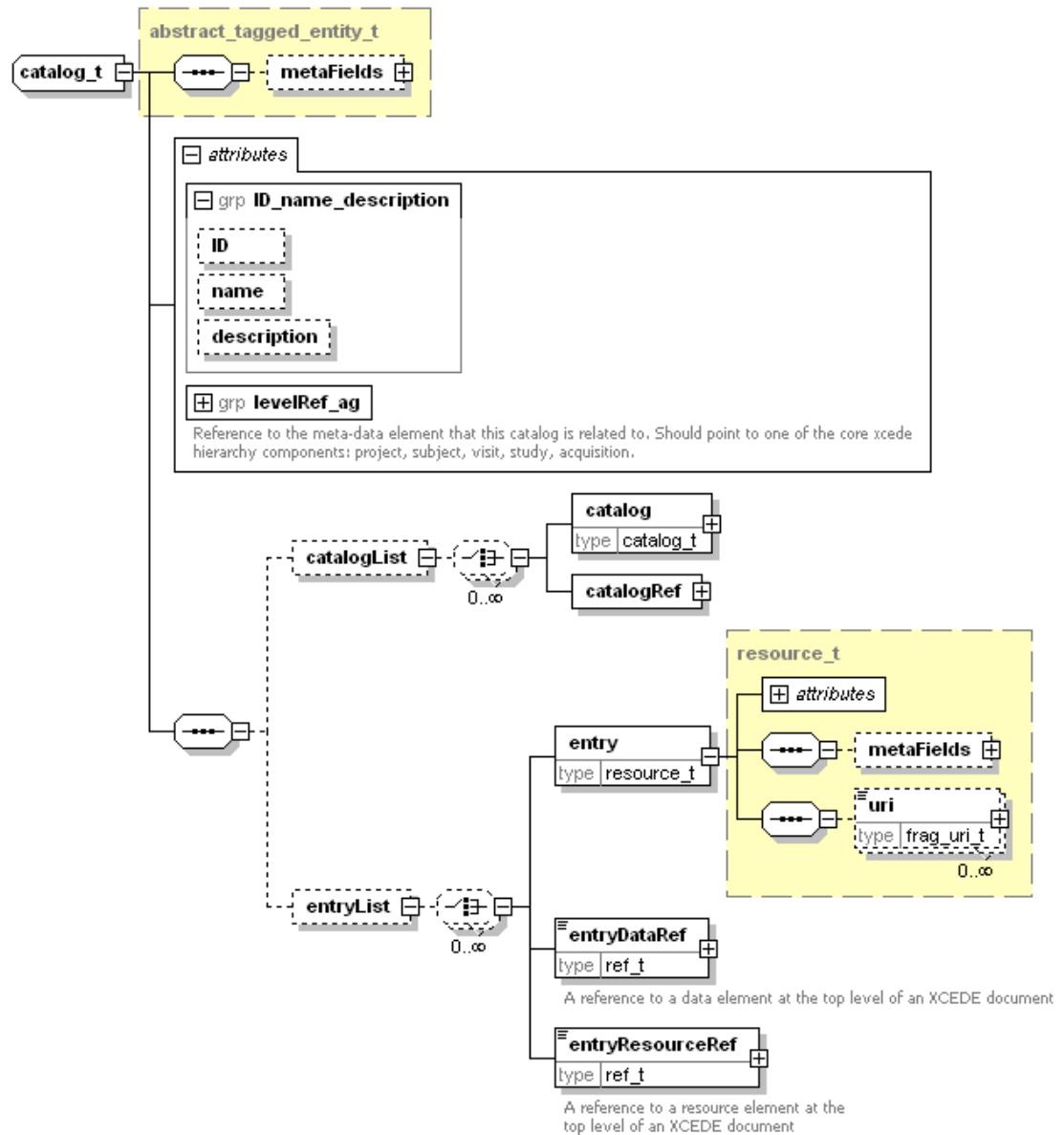
4.2. Examples

Figure 4.1. Catalog instance

```
<XCEDE>
<catalog ID="ID0">
  <catalogList>
    <catalog ID="ID1">
      <entryList>
        <entry ID="ID2" name="lh.pial" description="pial surface of left
hemisphere" format="FreeSurfer:surface-1" content="lh.pial" cachePath=""
uri="file://c:/data/fBIRN-AHM2006/fbph2-000648622547/surf/lh.pial"/>
        <entry ID="ID3" name="brain" description="extracted brain
mri" format="FreeSurfer:mgz-1" content="brain" cachePath=""
uri="file://c:/data/fBIRN-AHM2006/fbph2-000648622547/mri/brain.mgz"/>
        <entry ID="ID4" name="zstat8" description="8th zstatistic
contrast" format="nifti:nii-1" content="zstat8" cachePath=""
uri="file://c:/data/fBIRN-AHM2006/sirp-hp65-stc-to7-gam.feats/stats/zstat8.nii"/>
        <entry ID="ID5" name="aparc+aseg" description="parcellation and segmentation
label map" format="FreeSurfer:mgz-1" content="aparc+aseg" cachePath=""
uri="file://c:/data/fBIRN-AHM2006/fbph2-000648622547/mri/aparc+aseg.mgz"/>
      </entryList>
    </catalog>
  </catalogList>
</catalog ID="ID1">
  <entryList>
    <entry ID="ID2" name="lh.pial" description="pial surface of left
hemisphere" format="FreeSurfer:surface-1" content="lh.pial" cachePath=""
uri="file://c:/data/fBIRN-AHM2006/fbph2-000648622547/surf/lh.pial"/>
    <entry ID="ID3" name="brain" description="extracted brain
mri" format="FreeSurfer:mgz-1" content="brain" cachePath=""
uri="file://c:/data/fBIRN-AHM2006/fbph2-000648622547/mri/brain.mgz"/>
    <entry ID="ID4" name="zstat8" description="8th zstatistic
contrast" format="nifti:nii-1" content="zstat8" cachePath=""
uri="file://c:/data/fBIRN-AHM2006/sirp-hp65-stc-to7-gam.feats/stats/zstat8.nii"/>
    <entry ID="ID5" name="aparc+aseg" description="parcellation and segmentation
label map" format="FreeSurfer:mgz-1" content="aparc+aseg" cachePath=""
uri="file://c:/data/fBIRN-AHM2006/fbph2-000648622547/mri/aparc+aseg.mgz"/>
  </entryList>
</catalog>
</catalogList>
</catalog>
</XCEDE>
```

4.3. Reference

Figure 4.2. catalog_t



Chapter 5. Provenance

Provenance is used to record in detail the sequence of processing and analysis steps that have been executed to create a derived image and/or measures. These details include the name and type of machine on which the executable was run, the name of the executable, and input parameters to the executable.

5.1. Overview

XCEDE-represented studies will be populated with large numbers of medical image volumes which researchers will wish to access and run various processing tools on in order to obtain derived data. This derived data, such as volumes of various brain structures, cortical thickness etc., will then be placed back into the database, linked to the original volume from which it was produced. If a researcher would like to recreate the processing steps, in order to apply it to a new data set, they will be able to obtain the information needed to download or reconstruct the tools that were used on the original data set. Information about the processing tools needs to be made available by the authors of the tools, is collected at run time by the processing scripts, and written into XCDED.

5.2. Examples

5.3. Reference

Chapter 6. Events

6.1. Overview

Events in XCEDE are merely time intervals annotated with arbitrary metadata. This component can be used to represent several types of behavioral data, statistics calculated on time series data, or any other metadata whose proper interpretation requires that it be associated with a particular time interval.

An XCEDE event consists of the following:

onset	The onset (in seconds) of the time interval.
duration	The duration (in seconds) of the time interval.
type	Usage of this field is user-specified
name	Usage of this field is user-specified
units	The units of the onset and duration fields. This field is optional, and it is recommended that users of the schema prescribe an implicit unit of measurement and use it consistently. In that case, this field may be considered informational only.
values	A <i>value</i> adds named metadata to this event.

The following instance shows how each of these fields may be populated.

```
<event type="visual" name="event#1" units="sec">
  <onset>0</onset>
  <duration>2</duration>
  <value name="shape">square</value>
  <value name="shapecolor">red</value>
</event>
```

Event elements are stored within the `<data>` element of an `<acquisition>`. The `<data>` element should be of type `events_t` (using `xsi:type` — see examples below).

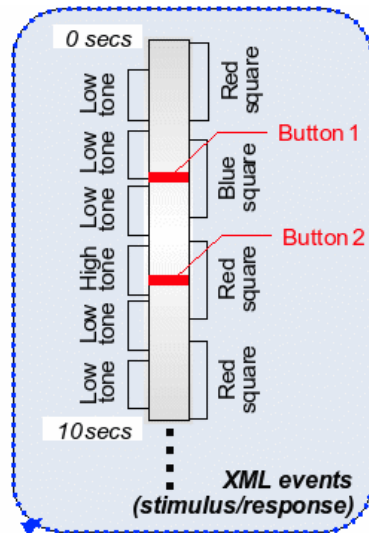
All onsets are relative to an arbitrary time reference. Typically, time 0 (zero) could mean the start of data acquisition. An event list may be interpreted as concurrent with data in other `<acquisition>` elements (which could be other event lists). If so, the same time reference should be used in all concurrent acquisition data.

There is no ordering constraint on events in a list. Applications should depend on using the `<onset>` elements to order the events chronologically if they so desire.

An optional `<params>` element may precede the first event in a list, and this element stores arbitrary metadata (using the same `<value>` element used above) that apply to all events in the list.

6.2. Examples

Figure 6.1. An event timeline



Consider the timeline shown in Figure 6.1, representing stimuli and responses in a neuroimaging study. We show in Figure 6.2 how the first 5 seconds' worth of the events might be represented in XCEDE.

Figure 6.2. XCEDE Events example - stimulus/response data

```

<XCEDE xmlns="http://www.xcede.org/xcede-2"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <acquisition ID="my_events">
    <data xsi:type="events_t">
      <event type="visual">
        <onset>0</onset>
        <duration>2</duration>
        <value name="shape">square</value>
        <value name="shapecolor">red</value>
      </event>
      <event type="visual">
        <onset>2.5</onset>
        <duration>2</duration>
        <value name="shape">square</value>
        <value name="shapecolor">blue</value>
      </event>
      <event type="audio">
        <onset>0.3</onset>
        <duration>1.4</onset>
        <value name="frequency">low</value>
      </event>
      <event type="audio">
        <onset>2.0</onset>
        <duration>1.4</onset>
        <value name="frequency">low</value>
      </event>
      <event type="audio">
        <onset>3.5</onset>
        <duration>1.4</onset>
        <value name="frequency">low</value>
      </event>
      <event type="response">
        <onset>3.4</onset>
        <value name="button">1</value>
      </event>
    </data>
  </acquisition>
</XCEDE>

```

Each stimulus and each response are stored as separate event elements. Note that all the visual events appear first in the XCEDE file, then the audio events, and then the response event. This ordering is arbitrary, and the events could easily have been presented in chronological (or random!) order. The semantic interpretation of the events within an event list must not depend on their document order.

Stimulus and response data are not the only appropriate content to represent in XCEDE events. Figure 6.3 shows how quality assurance (QA) statistics for each volume/timepoint in an fMRI scan can be stored as events. Note that the time reference for the onsets is arbitrary, but if the acquisition containing the event data is contained within the same episode as other time-locked data, it should be assumed that the time reference is the same for all acquisitions within the episode, unless otherwise explicitly specified. So, for example, this QA data might be associated with MR image data in the same episode, and time 0 (zero) would by default be assumed to have the same meaning in both sets of data.

Figure 6.3. XCEDE Events example - QA data

```
<XCEDE xmlns="http://www.xcede.org/xcede-2"
        xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <acquisition ID="my_events">
    <data xsi:type="events_t">
      <event>
        <onset>0</onset>
        <duration>2</duration>
        <value name="volmean">759.218</value>
        <value name="cmassx">106.781</value>
        <value name="cmassy">118.279</value>
        <value name="cmassz">66.9694</value>
      </event>
      <event>
        <onset>2</onset>
        <duration>2</duration>
        <value name="volmean">759.218</value>
        <value name="cmassx">106.801</value>
        <value name="cmassy">118.242</value>
        <value name="cmassz">67.1636</value>
      </event>
      <!-- ... etc. ... -->
    </data>
  </acquisition>
</XCEDE>
```

Chapter 7. Assessments

This is where the assessment text goes.

7.1. Overview

7.2. Examples

7.3. Reference

Chapter 8. Protocols

8.1. Overview

8.2. Examples

8.3. Reference

Chapter 9. Analysis

This is where the analysis text goes.

9.1. Overview

9.2. Examples

9.3. Reference

Chapter 10. Terminology

This is where the terminology text goes.

10.1. Overview

10.2. Examples

10.3. Reference

Part II. Using and Extending XCEDE 2.0

This section of the XCEDE 2.0 manual provides practical lessons on using the schema, as well as discussions on how to use W3C XML Schema to extend the core XCEDE 2.0 datatypes and how to integrate it into applications, databases and web services.

Chapter 11. A Use Case

11.1. Overview

11.2. Examples

11.3. Reference

Chapter 12. Extending the Schema

12.1. Overview

12.2. Examples

12.3. Reference

Chapter 13. Integration With Applications and Services

13.1. Overview

13.2. Examples

13.3. Reference

Appendix A. Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSPY v2004 rel. 3 U (http://www.xmlspy.com) by dbk (UNIV CA IRVINE)
-->
<xs:schema xmlns="http://www.xcede.org/xcede-2"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:sch="http://purl.oclc.org/dsdl/schematron"
  xmlns:gml="http://www.opengis.net/gml" targetNamespace="http://www.xcede.org/xcede-2"
  elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xs:import namespace="http://www.opengis.net/gml"
    schemaLocation="http://schemas.opengis.net/gml/3.1.1/base/gml.xsd"/>
  <xs:annotation>
    <xs:documentation>The XCEDE schema provides an extensive metadata hierarchy for
    describing and documenting research and clinical studies. The schema organizes
    information into five general hierarchical levels: a complete project; studies within
    a project; subjects involved in the studies; visits for each of the subjects; the full
    description of the subject's participation during each visit</xs:documentation>
    <xs:documentation>Each of these sub-schemas is composed of information relevant to
    that aspect of an experiment and can be stored in separate XML files or spliced into
    one large file allowing for the XML data to be stored in a hierarchical directory
    structure along with the primary data. Each sub-schema also allows for the storage
    of data provenance information allowing for a traceable record of processing and/or
    changes to the underlying data. Additionally, the sub-schemas contain support for
    derived statistical data in the form of human imaging activation maps and simple
    statistical value lists.</xs:documentation>
    <xs:documentation>XCEDE was originally designed in the context of neuroimaging
    studies and complements the Biomedical Informatics Research Network (BIRN) Human
    Imaging Database, an extensible database and intuitive web-based user interface for
    the management, discovery, retrieval, and analysis of clinical and brain imaging data.
    This close coupling allows for an interchangeable source-sink relationship between the
    database and the XML files, which can be used for the import/export of data to/from
    the database, the standardized transport and interchange of experimental data, the
    local storage of experimental information within data collections, and human and
    machine readable description of the actual data.</xs:documentation>
  </xs:annotation>
  <xs:element name="XCEDE">
    <xs:complexType>
      <xs:choice minOccurs="0" maxOccurs="unbounded">
        <xs:element name="annotationList" minOccurs="0">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="annotation" type="textAnnotation_t" minOccurs="0"
maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="revisionList" minOccurs="0">
          <xs:annotation>
            <xs:documentation>container for document revision history</xs:documentation>
          </xs:annotation>
          <xs:complexType>
            <xs:sequence>
              <xs:element name="revision" type="revision_t" minOccurs="0"
maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="project" type="project_t" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="subject" type="subject_t" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="visit" type="visit_t" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="study" type="study_t" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="episode" type="episode_t" minOccurs="0" maxOccurs="unbounded"/>
      </xs:choice>
    </xs:complexType>
  </xs:element>
```

```

    <xs:element name="acquisition" type="acquisition_t" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="catalog" type="catalog_t" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="analysis" type="analysis_t" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="resource" type="resource_t" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="protocol" type="protocol_t" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="data" type="abstract_data_t" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:choice>
  <xs:attribute name="version" type="xs:string"/>
</xs:complexType>
</xs:element>
<!--***** Top-level containers *****-->
<xs:complexType name="project_t">
  <xs:complexContent>
    <xs:extension base="abstract_container_t">
      <xs:sequence>
        <xs:element name="projectInfo" type="projectInfo_t" minOccurs="0"/>
        <xs:element name="contributorList" minOccurs="0">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="contributor" type="person_t" minOccurs="0"
maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="subjectGroup_t">
  <xs:annotation>
    <xs:documentation>There should be one of these elements for each subject group in
this
  project (e.g. control, patient).</xs:documentation>
  </xs:annotation>
  <xs:sequence>
    <xs:element name="subjectID" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="ID"/>
  <xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:complexType>
<xs:complexType name="subject_t">
  <xs:complexContent>
    <xs:extension base="abstract_container_t">
      <xs:sequence>
        <xs:element name="subjectInfo" type="subjectInfo_t" minOccurs="0"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="visit_t">
  <xs:complexContent>
    <xs:extension base="abstract_container_t">
      <xs:sequence>
        <xs:element name="visitInfo" type="visitInfo_t" minOccurs="0"/>
        <xs:any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attributeGroup ref="visitExternalIDs_ag"/>
      <xs:anyAttribute namespace="##other" processContents="lax"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="study_t">
  <xs:complexContent>
    <xs:extension base="abstract_container_t">

```

```
<xs:sequence>
  <xs:element name="studyInfo" type="studyInfo_t" minOccurs="0"/>
  <xs:any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
</xs:sequence>
<xs:attributeGroup ref="studyExternalIDs_ag"/>
<xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="studyInfo_t">
  <xs:complexContent>
    <xs:extension base="abstract_info_t"/>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="episode_t">
  <xs:complexContent>
    <xs:extension base="abstract_container_t">
      <xs:sequence>
        <xs:element name="episodeInfo" type="episodeInfo_t" minOccurs="0"/>
        <xs:any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attributeGroup ref="episodeExternalIDs_ag"/>
      <xs:anyAttribute namespace="##other" processContents="lax"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="acquisition_t">
  <xs:complexContent>
    <xs:extension base="abstract_container_t">
      <xs:sequence>
        <xs:element name="acquisitionInfo" type="acquisitionInfo_t" minOccurs="0"/>
        <xs:choice minOccurs="0">
          <xs:element name="dataResourceRef" type="ref_t">
            <xs:annotation>
              <xs:documentation>A reference to a resource as described above. The
                resource could be part of a catalog, a root level resource,
                etc.</xs:documentation>
            </xs:annotation>
          </xs:element>
          <xs:element name="dataRef" type="ref_t">
            <xs:annotation>
              <xs:documentation>A reference to a container that the actual
                acquisition data goes into (as opposed to being in an external
                non-XCEDE format)</xs:documentation>
            </xs:annotation>
          </xs:element>
        </xs:choice>
        <xs:any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute name="acquisitionProtocol" use="optional"/>
      <xs:attributeGroup ref="acquisitionExternalIDs_ag"/>
      <xs:anyAttribute namespace="##other" processContents="lax"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="analysis_t">
  <xs:annotation>
    <xs:documentation>A collection of output from ana analysis of
      data.</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="abstract_container_t">
      <xs:sequence>
        <xs:element name="provenance" type="provenance_t" minOccurs="0"
          maxOccurs="unbounded">
          <xs:annotation>
```

```

        <xs:documentation>The record of the origin and transformations applied to source
data that produced this analysis</xs:documentation>
    </xs:annotation>
</xs:element>
<xs:element name="inputRef" type="analysisRef_t" minOccurs="0"
maxOccurs="unbounded"/>
<xs:element name="outputRef" type="analysisRef_t" minOccurs="0"/>
<xs:element name="measurementGroup" type="measurementGroup_t"
maxOccurs="unbounded">
    <xs:annotation>
        <xs:documentation>A measurementGroup contains information and data related
to the outcome of an analysis. For example, this could be a statistic (e.g.
from a Statistical Parametric Map) or a measurement (e.g. the volume of the
hippocampus).</xs:documentation>
    </xs:annotation>
</xs:element>
<xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="dataResourceRef" type="ref_t">
        <xs:annotation>
            <xs:documentation>A reference to a resource as described above. The
resource could be part of a catalog, a root level resource,
etc.</xs:documentation>
        </xs:annotation>
    </xs:element>
    <xs:element name="dataRef" type="ref_t">
        <xs:annotation>
            <xs:documentation>A reference to a container that the actual
acquisition data goes into (as opposed to being in an external
non-XCEDE format)</xs:documentation>
        </xs:annotation>
    </xs:element>
</xs:choice>
</xs:sequence>
</xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="observation_t">
    <xs:annotation>
        <xs:documentation>Observations that are made concerning an entity (e.g. in a
measurementGroup). For example, following the hippocampus example, might be the total
volume, surface area, etc.</xs:documentation>
    </xs:annotation>
    <xs:simpleContent>
        <xs:extension base="xs:string">
            <xs:attribute name="name" type="xs:string" use="required">
                <xs:annotation>
                    <xs:documentation>The name (preferred label) of the observation
value</xs:documentation>
                </xs:annotation>
            </xs:attribute>
            <xs:attribute name="units" type="xs:string" use="optional">
                <xs:annotation>
                    <xs:documentation>The measurement units for the returned value of the
observation</xs:documentation>
                </xs:annotation>
            </xs:attribute>
            <xs:attribute name="type" type="valueTypes_t" use="optional">
                <xs:annotation>
                    <xs:documentation>The declared data type for the returned value of the
observation</xs:documentation>
                </xs:annotation>
            </xs:attribute>
        </xs:extension>
    </xs:simpleContent>
</xs:complexType>
<xs:complexType name="protocol_t">
    <xs:complexContent>

```

```
<xs:extension base="abstract_protocol_t">
  <xs:sequence>
    <xs:element name="steps" minOccurs="0">
      <xs:complexType>
        <xs:choice minOccurs="0" maxOccurs="unbounded">
          <xs:element name="step" type="protocol_t"/>
          <xs:element name="stepRef" type="ref_t"/>
        </xs:choice>
      </xs:complexType>
    </xs:element>
    <xs:element name="items" minOccurs="0">
      <xs:complexType>
        <xs:sequence>
          <xs:element name="item" type="protocolItem_t" minOccurs="0"
maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="catalog_t">
  <xs:complexContent>
    <xs:extension base="abstract_tagged_entity_t">
      <xs:sequence>
        <xs:element name="catalogList" minOccurs="0">
          <xs:complexType>
            <xs:choice minOccurs="0" maxOccurs="unbounded">
              <xs:element name="catalog" type="catalog_t"/>
              <xs:element name="catalogRef">
                <xs:complexType>
                  <xs:attribute name="catalogID" type="xs:string"/>
                </xs:complexType>
              </xs:element>
            </xs:choice>
          </xs:complexType>
        </xs:element>
        <xs:element name="entryList" minOccurs="0">
          <xs:complexType>
            <xs:choice minOccurs="0" maxOccurs="unbounded">
              <xs:element name="entry" type="resource_t"/>
              <xs:element name="entryDataRef" type="ref_t">
                <xs:annotation>
                  <xs:documentation>A reference to a data element at the top
                    level of an XCEDE document</xs:documentation>
                </xs:annotation>
              </xs:element>
              <xs:element name="entryResourceRef" type="ref_t">
                <xs:annotation>
                  <xs:documentation>A reference to a resource element at the
                    top level of an XCEDE document</xs:documentation>
                </xs:annotation>
              </xs:element>
            </xs:choice>
          </xs:complexType>
        </xs:element>
      </xs:sequence>
      <xs:attributeGroup ref="ID_name_description"/>
      <xs:attributeGroup ref="levelRef_ag"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="resource_t">
  <xs:annotation>
    <xs:documentation>A resource is something that we haven't agreed on
yet.</xs:documentation>
```



```
</xs:annotation>
<xs:complexContent>
  <xs:extension base="abstract_tagged_entity_t">
    <xs:sequence>
      <xs:element name="uri" type="frag_uri_t" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attributeGroup ref="ID_name_description"/>
    <xs:attributeGroup ref="levelRef_ag"/>
    <xs:attribute name="format" type="xs:string" use="optional">
      <xs:annotation>
        <xs:documentation>Format of file. E.g. DICOM, Analyze,
          4dfp</xs:documentation>
      </xs:annotation>
    </xs:attribute>
    <xs:attribute name="content" type="xs:string" use="optional">
      <xs:annotation>
        <xs:documentation>Code indicating the contents of the image. E.g. GFC,
          T88</xs:documentation>
      </xs:annotation>
    </xs:attribute>
    <xs:attribute name="cachePath" use="optional">
      <xs:simpleType>
        <xs:restriction base="xs:string">
          <xs:maxLength value="255"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
  </xs:extension>
</xs:complexContent>
</xs:complexType>
<!--*****      Top-level ID attribute groups      *****-->
<xs:attributeGroup name="visitExternalIDs_ag">
  <xs:attribute name="projectID" type="xs:string">
    <xs:annotation>
      <xs:documentation>The content of this attribute should match the ID attribute of
the
  project_t to which this element is associated.</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="projectURI" type="xs:string">
    <xs:annotation>
      <xs:documentation>This is the location of a document where to find an element
        matching the projectID (see projectID attribute).</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="subjectID" type="xs:string">
    <xs:annotation>
      <xs:documentation>The content of this attribute should match the ID attribute of
the
  subject_t to which this element is associated.</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="subjectURI" type="xs:string">
    <xs:annotation>
      <xs:documentation>This is the location of a document where to find an element
        matching the subjectID (see subjectID attribute).</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="subjectGroupID" type="xs:string">
    <xs:annotation>
      <xs:documentation>content of this attribute should match the ID of one of the
        subject groups listed in the project_t associated with this element (see
        projectID and project_t).</xs:documentation>
    </xs:annotation>
  </xs:attribute>
</xs:attributeGroup>
<xs:attributeGroup name="studyExternalIDs_ag">
```

```
<xs:attributeGroup ref="visitExternalIDs_ag"/>
<xs:attribute name="visitID" type="xs:string">
  <xs:annotation>
    <xs:documentation>The content of this attribute should match the ID attribute of
the
    visit_t to which this element is associated.</xs:documentation>
  </xs:annotation>
</xs:attribute>
<xs:attribute name="visitURI" type="xs:string">
  <xs:annotation>
    <xs:documentation>This is the location of a document where to find an element
    matching the visitID (see visitID attribute).</xs:documentation>
  </xs:annotation>
</xs:attribute>
</xs:attributeGroup>
<xs:attributeGroup name="episodeExternalIDs_ag">
  <xs:attributeGroup ref="studyExternalIDs_ag"/>
  <xs:attribute name="studyID" type="xs:string">
    <xs:annotation>
      <xs:documentation>The content of this attribute should match the ID attribute of
the
      study_t to which this element is associated.</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="studyURI" type="xs:string">
    <xs:annotation>
      <xs:documentation>This is the location of a document where to find an element
      matching the studyID (see studyID attribute).</xs:documentation>
    </xs:annotation>
  </xs:attribute>
</xs:attributeGroup>
<xs:attributeGroup name="acquisitionExternalIDs_ag">
  <xs:attributeGroup ref="episodeExternalIDs_ag"/>
  <xs:attribute name="episodeID" type="xs:string">
    <xs:annotation>
      <xs:documentation>The content of this attribute should match the ID attribute of
the
      episode_t to which this element is associated.</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="episodeURI" type="xs:string">
    <xs:annotation>
      <xs:documentation>This is the location of a document where to find an element
      matching the episodeID (see episodeID attribute).</xs:documentation>
    </xs:annotation>
  </xs:attribute>
</xs:attributeGroup>
<xs:attributeGroup name="allLevelExternalIDs_ag">
  <xs:attributeGroup ref="acquisitionExternalIDs_ag"/>
  <xs:attribute name="acquisitionID" type="xs:string">
    <xs:annotation>
      <xs:documentation>The content of this attribute should match the ID attribute of
the
      acquisition_t to which this element is associated.</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="acquisitionURI" type="xs:string">
    <xs:annotation>
      <xs:documentation>This is the location of a document where to find an element
      matching the acquisitionID (see acquisitionID attribute).</xs:documentation>
    </xs:annotation>
  </xs:attribute>
</xs:attributeGroup>
<xs:attributeGroup name="levelRef_ag">
  <xs:annotation>
    <xs:documentation>Reference to the meta-data element that this catalog is related
to.
```

```

    Should point to one of the core xcede hierarchy components: project, subject,
    visit,
    study, acquisition.</xs:documentation>
  </xs:annotation>
  <xs:attribute name="level" type="levelDescriptor_t"/>
  <xs:attributeGroup ref="allLevelExternalIDs_ag"/>
</xs:attributeGroup>
<!--***** Abstract types *****-->
<xs:complexType name="abstract_data_t" abstract="true">
  <xs:complexContent>
    <xs:extension base="abstract_container_t">
      <xs:attributeGroup ref="levelRef_ag"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="abstract_container_t" abstract="true">
  <xs:sequence>
    <xs:element name="commentList" minOccurs="0">
      <xs:annotation>
        <xs:documentation>A comment is a description of the entity referred to by
the current element. For example, a description of a particular subject or
series.</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:sequence>
          <xs:element name="comment" type="authoredText_t" minOccurs="0"
maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:element name="annotationList" minOccurs="0">
      <xs:annotation>
        <xs:documentation>An annotation is a description related to the xml document and
the current element. Fore example, some processing that ahs edited content in the
element itself.</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:sequence>
          <xs:element name="annotation" type="textAnnotation_t" minOccurs="0"
maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:element name="resourceList" minOccurs="0">
      <xs:annotation>
        <xs:documentation>Informational resources related to the
container</xs:documentation>
      </xs:annotation>
      <xs:complexType>
        <xs:sequence>
          <xs:element name="resource" type="informationResource_t" minOccurs="0"
maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:attribute name="ID" type="xs:string"/>
<xs:attribute name="rev" type="xs:string">
  <xs:annotation>
    <xs:documentation>Revision number, should correspond with an appropriate revision
ID
    in the XCEDE/history element</xs:documentation>
  </xs:annotation>
</xs:attribute>
<xs:attribute name="type" type="xs:string">
  <xs:annotation>
    <xs:documentation>Attribute for creating categories within a container set. For

```

```

        example, within study, types might include 'PET' or 'MR'. One could also create
        sub-classes using colon notation: "MR:STRUCT"</xs:documentation>
    </xs:annotation>
</xs:attribute>
<xs:attributeGroup ref="terminology_ag"/>
</xs:complexType>
<xs:complexType name="abstract_entity_t" abstract="true">
    <xs:annotation>
        <xs:documentation>entity elements are used to describe the resultant scope of an
        analysis (e.g. anatomical entity, atlas entity)</xs:documentation>
    </xs:annotation>
    <xs:sequence>
        <xs:element name="description" type="xs:string" minOccurs="0"/>
    </xs:sequence>
    <xs:attribute name="ID" type="xs:string"/>
    <xs:attribute name="preferredEntityLabel" type="xs:string" use="required">
        <xs:annotation>
            <xs:documentation>Preferred Name for the Entity</xs:documentation>
        </xs:annotation>
    </xs:attribute>
</xs:complexType>
<xs:complexType name="abstract_info_t" abstract="true">
    <xs:annotation>
        <xs:documentation>info elements are present in each of the hierarchy levels. these
        can
        be extended to capture instance specific content (following recommendation
        5)</xs:documentation>
    </xs:annotation>
    <xs:sequence>
        <xs:element name="description" type="xs:string" minOccurs="0"/>
    </xs:sequence>
</xs:complexType>
<xs:complexType name="abstract_protocol_t" abstract="true">
    <xs:sequence>
        <xs:element name="protocolOffset" type="protocolOffset_t" minOccurs="0"
        maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attributeGroup ref="ID_name_description"/>
    <xs:attributeGroup ref="terminology_ag"/>
    <xs:attribute name="level" type="levelDescriptor_t">
        <xs:annotation>
            <xs:documentation>Describes the level of the XCEDE hierarchy that this protocol
            instance should be validated against</xs:documentation>
        </xs:annotation>
    </xs:attribute>
    <xs:attribute name="required" type="xs:boolean"/>
    <xs:attribute name="minOccurences" type="xs:integer"/>
    <xs:attribute name="maxOccurences" type="xs:integer">
        <xs:annotation>
            <xs:documentation>Are these occurences within a step (i.e. during a single time
            point)? How to refer to repeats across steps?</xs:documentation>
        </xs:annotation>
    </xs:attribute>
    <xs:attribute name="minTimeFromStart" type="xs:string">
        <xs:annotation>
            <xs:documentation>Absolute time from start of overall protocol</xs:documentation>
        </xs:annotation>
    </xs:attribute>
    <xs:attribute name="maxTimeFromStart" type="xs:string"/>
</xs:complexType>
<!--***** Misc. types *****-->
<xs:complexType name="projectInfo_t">
    <xs:complexContent>
        <xs:extension base="abstract_info_t">
            <xs:sequence>
                <xs:element name="exptDesignList" minOccurs="0">
                    <xs:complexType>

```

```

    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="exptDesign"/>
      <xs:element name="exptDesignRef" type="ref_t"/>
    </xs:choice>
  </xs:complexType>
</xs:element>
<xs:element name="subjectGroupList" minOccurs="0">
  <xs:annotation>
    <xs:documentation>This provides a mapping of subjects to subject groups
      within projects. A subject can be a member of subject groups in
      multiple projects.</xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence>
      <xs:element name="subjectGroup" type="subjectGroup_t" minOccurs="0"
maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:anyAttribute namespace="##other" processContents="lax"/>
  </xs:complexType>
</xs:element>
<xs:any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
</xs:sequence>
<xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="subjectInfo_t">
  <xs:complexContent>
    <xs:extension base="abstract_info_t">
      <xs:sequence>
        <xs:element name="sex" type="terminologyString_t" minOccurs="0"/>
        <xs:element name="species" type="terminologyString_t" minOccurs="0"/>
        <xs:element name="birthdate" type="terminologyString_t" minOccurs="0"/>
        <xs:any namespace="##other" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:anyAttribute namespace="##other" processContents="lax"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="visitInfo_t">
  <xs:complexContent>
    <xs:extension base="abstract_info_t">
      <xs:sequence>
        <xs:element name="timeStamp" type="xs:dateTime" minOccurs="0"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="episodeInfo_t">
  <xs:complexContent>
    <xs:extension base="abstract_info_t"/>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="acquisitionInfo_t">
  <xs:complexContent>
    <xs:extension base="abstract_info_t"/>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="measurementGroup_t">
  <xs:annotation>
    <xs:documentation>A measurementGroup contains information and data related
to the outcome of an analysis. For example, this could be a statistic (e.g.
from a Statistical Parametric Map) or a measurement (e.g. the volume of the
hippocampus).</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="abstract_container_t">

```

```
<xs:sequence>
  <xs:element name="entity" type="abstract_entity_t" maxOccurs="unbounded">
    <xs:annotation>
      <xs:documentation>In the context of a measurement Group, is the entity being
measured. For example, the hippocampus. </xs:documentation>
    </xs:annotation>
  </xs:element>
  <xs:element name="observation" type="observation_t" maxOccurs="unbounded">
    <xs:annotation>
      <xs:documentation>In the context of a measurement Group, are the observations
that are made concerning the entity. For example, following hte hippocmapus example,
might be the total volume, surface area, etc.</xs:documentation>
    </xs:annotation>
  </xs:element>
</xs:sequence>
</xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="nomenclature_t">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="abbreviation" type="xs:string"/>
      <xs:attribute name="nomenclature" type="xs:string"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="atlasEntityGML_t">
  <xs:annotation>
    <xs:documentation>entity elements are used to describe the resultant scope of an
analysis</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="abstract_entity_t">
      <xs:sequence>
        <xs:element name="atlasEntity" type="gml:AbstractGeometryType">
          <xs:annotation>
            <xs:documentation>Atlas entity defined through the use of GML base
geometries.</xs:documentation>
          </xs:annotation>
        </xs:element>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="anatomicalEntity_t">
  <xs:annotation>
    <xs:documentation>Entity elements are used to describe the resultant scope of an
analysis</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="abstract_entity_t">
      <xs:sequence>
        <xs:element name="label" type="terminologyString_t" minOccurs="0"
maxOccurs="unbounded">
          <xs:annotation>
            <xs:documentation>The set of terms that name this entity. This set can contain
a collection of synonymous terms</xs:documentation>
          </xs:annotation>
        </xs:element>
      </xs:sequence>
      <xs:attribute name="laterality" type="laterality_t" use="optional">
        <xs:annotation>
          <xs:documentation>Laterality of region (or none) </xs:documentation>
        </xs:annotation>
      </xs:attribute>
      <xs:attribute name="tissueType" type="tissueType_t" use="optional">
        <xs:annotation>
```

```
        <xs:documentation>Tissue type of region (or none) </xs:documentation>
      </xs:annotation>
    </xs:attribute>
  </xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="protocolItem_t">
  <xs:sequence>
    <xs:element name="itemText" minOccurs="0">
      <xs:complexType>
        <xs:sequence>
          <xs:element name="textLabel" minOccurs="0" maxOccurs="unbounded">
            <xs:complexType>
              <xs:attribute name="location" use="required"/>
              <xs:attribute name="value" type="xs:string" use="required"/>
            </xs:complexType>
          </xs:element>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:choice>
      <xs:element name="itemRange" type="protocolItemRange_t" minOccurs="0"
maxOccurs="unbounded"/>
      <xs:element name="itemChoice" minOccurs="0" maxOccurs="unbounded">
        <xs:complexType>
          <xs:attribute name="itemCode" type="xs:string"/>
          <xs:attribute name="itemValue" type="xs:string"/>
          <xs:attribute name="ID" type="xs:string"/>
          <xs:attribute name="units" type="xs:string"/>
        </xs:complexType>
      </xs:element>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="name" type="xs:string"/>
  <xs:attribute name="ID" type="xs:string"/>
  <xs:attribute name="required" type="xs:boolean"/>
</xs:complexType>
<xs:complexType name="nameValue_t">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="name" type="xs:string"/>
      <xs:anyAttribute processContents="lax"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="metadataList_t">
  <xs:sequence>
    <xs:element name="value" type="nameValue_t" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="ref_t">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="ID" type="xs:string"/>
      <xs:attribute name="URI" type="xs:string"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="assessmentInfo_t">
  <xs:complexContent>
    <xs:extension base="abstract_info_t"/>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="assessment_t">
  <xs:complexContent>
    <xs:extension base="abstract_data_t">
      <xs:sequence>
```

```
<xs:element name="name" type="xs:string"/>
<xs:element name="dataInstance" minOccurs="0" maxOccurs="unbounded">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="assessmentInfo" type="assessmentInfo_t" minOccurs="0">
        <xs:annotation>
          <xs:documentation>Block for describing things like
            informant, clinical rater, assessment date,
            etc</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="assessmentItem" type="assessmentItem_t" minOccurs="0"
maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="validated" type="xs:boolean">
      <xs:annotation>
        <xs:documentation>Indicates whether the instance has been
          validated (e.g. by reconciling double-entry instances).
          There should be only one validated instance per
          assessment.</xs:documentation>
      </xs:annotation>
    </xs:attribute>
  </xs:complexType>
</xs:element>
  <xs:element name="annotation" type="textAnnotation_t" minOccurs="0"
maxOccurs="unbounded"/>
</xs:sequence>
</xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="assessmentDescItem_t">
  <xs:complexContent>
    <xs:extension base="protocolItem_t">
      <xs:attribute name="version" type="xs:string"/>
      <xs:attribute name="formRef" type="xs:string"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="assessmentItem_t">
  <xs:sequence>
    <xs:element name="valueStatus" type="xs:string" minOccurs="0">
      <xs:annotation>
        <xs:documentation>Information on the status of a value (e.g. subject refused to
          answer)</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="value" type="value_t">
      <xs:annotation>
        <xs:documentation>Actual value of the assessment item as recorded on the
          form</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="normValue" type="value_t" minOccurs="0">
      <xs:annotation>
        <xs:documentation>Normalized or scaled value of the assessment
          item</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="reconciliationNote" type="textAnnotation_t" minOccurs="0">
      <xs:annotation>
        <xs:documentation>Normalized or scaled value of the assessment
          item</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="annotation" type="textAnnotation_t" minOccurs="0"/>
  </xs:sequence>
<xs:attributeGroup ref="terminology_ag"/>
```



```
<xs:attribute name="ID"/>
<xs:attribute name="name"/>
</xs:complexType>
<xs:complexType name="investigator_t">
  <xs:complexContent>
    <xs:extension base="person_t"/>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="authoredText_t">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attributeGroup ref="authoredText_ag"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="abstract_annotation_t" abstract="true">
  <xs:attributeGroup ref="authoredText_ag"/>
</xs:complexType>
<xs:complexType name="textAnnotation_t">
  <xs:complexContent>
    <xs:extension base="abstract_annotation_t">
      <xs:sequence>
        <xs:element name="text" type="xs:string" minOccurs="0"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="nsTermAnnotation_t">
  <xs:complexContent>
    <xs:extension base="abstract_annotation_t">
      <xs:sequence>
        <xs:element name="ontologyClass" type="xs:string" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="nsOntologyAnnotation_t">
  <xs:complexContent>
    <xs:extension base="abstract_annotation_t">
      <xs:sequence>
        <xs:element name="term" type="xs:string" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="generator_t">
  <xs:sequence>
    <xs:element name="application" type="versionedEntity_t">
      <xs:annotation>
        <xs:documentation>Program used to generate document</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="invocation" type="xs:string">
      <xs:annotation>
        <xs:documentation>Application input required to generate this document. Should
          be explicit such that this document can be re-generated from this
          info</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="dataSource" type="xs:string" minOccurs="0">
      <xs:annotation>
        <xs:documentation>Description of data source with version numbers and/or
          timestamp of data</xs:documentation>
      </xs:annotation>
    </xs:element>
  </xs:sequence>
</xs:complexType>
```

```
<xs:attributeGroup name="authoredText_ag">
  <xs:attribute name="author" type="xs:string"/>
  <xs:attribute name="timestamp" type="xs:dateTime"/>
</xs:attributeGroup>
<xs:attributeGroup name="terminology_ag">
  <xs:attribute name="preferredLabel" type="xs:string" use="required">
    <xs:annotation>
      <xs:documentation>The preferred label of this term. This can be different than the
term used by the applications (e.g. CBLM versus cerebellum)</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="abbreviation" type="xs:string" use="optional">
    <xs:annotation>
      <xs:documentation>The preferred abbreviation for the term</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="nomenclature" type="xs:string" use="required">
    <xs:annotation>
      <xs:documentation>The source ontology of this terminology/ontology
term</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="termID" type="xs:string" use="required">
    <xs:annotation>
      <xs:documentation>Applications will likely want to constrain what are valid IDs
      within the context of their application (for example, allowing only
      LSID's)</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="termPath" type="xs:string" use="optional"/>
</xs:attributeGroup>
<xs:simpleType name="uniqueID_t">
  <xs:annotation>
    <xs:documentation> Having a distinct unique ID type is a convenience for building
referential links. The reason we are not using the native XML Schema ID attribute
is
    that enforces document-wide uniqueness, whereas there may be instances of this
    bioterm schema that contain multiple namespace-qualified term or ontology class
    sets
    where IDs are unique within their namespace but not across the entire document.
  </xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string">
    <xs:pattern value="[A-Za-z0-9\-\:\_\.]+\"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="person_t">
  <xs:annotation>
    <xs:documentation>Add additional fields (address, email, etc)</xs:documentation>
  </xs:annotation>
  <xs:sequence>
    <xs:element name="salutation" type="xs:string" minOccurs="0">
      <xs:annotation>
        <xs:documentation>e.g. Dr., Mr., Mrs.</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="givenName" type="xs:string" minOccurs="0"/>
    <xs:element name="middleName" type="xs:string" minOccurs="0"/>
    <xs:element name="surname" type="xs:string" minOccurs="0">
      <xs:annotation>
        <xs:documentation>Used for last name or only name (e.g.
        Prince)</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="academicTitles" type="xs:string" minOccurs="0"/>
    <xs:element name="institution" type="xs:string" minOccurs="0"/>
    <xs:element name="department" type="xs:string" minOccurs="0"/>
```

```
</xs:sequence>
<xs:attribute name="ID" type="xs:string"/>
<xs:attribute name="role" type="xs:string"/>
</xs:complexType>
<xs:complexType name="mixedType_t" mixed="true"/>
<xs:complexType name="versionedEntity_t">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="version" type="xs:string"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:simpleType name="levelDescriptor_t">
  <xs:restriction base="xs:string">
    <xs:enumeration value="project"/>
    <xs:enumeration value="subject"/>
    <xs:enumeration value="visit"/>
    <xs:enumeration value="study"/>
    <xs:enumeration value="episode"/>
    <xs:enumeration value="acquisition"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="protocolOffset_t">
  <xs:sequence>
    <xs:element name="protocolTimeRef" type="unitString_t" minOccurs="0"/>
    <xs:element name="preferedTimeOffset" type="unitString_t" minOccurs="0"/>
    <xs:element name="minTimeOffset" type="unitString_t" minOccurs="0"/>
    <xs:element name="maxTimeOffset" type="unitString_t" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="protocolItemChoice_t">
  <xs:sequence>
    <xs:element name="value" type="xs:string" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="units" type="xs:string"/>
</xs:complexType>
<xs:complexType name="protocolItemRange_t">
  <xs:attribute name="min" type="xs:string">
    <xs:annotation>
      <xs:documentation>Minimum value for item (inclusive)</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="max" type="xs:string">
    <xs:annotation>
      <xs:documentation>Maximum value for item (inclusive)</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="units" type="xs:string"/>
</xs:complexType>
<xs:attributeGroup name="ID_name_description">
  <xs:attribute name="ID" type="xs:string"/>
  <xs:attribute name="name" type="xs:string"/>
  <xs:attribute name="description" type="xs:string"/>
</xs:attributeGroup>
<xs:complexType name="terminologyString_t">
  <xs:annotation>
    <xs:documentation>A simple representation of terms for use within the
schema.</xs:documentation>
  </xs:annotation>
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attributeGroup ref="terminology_ag"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="admin">
  <xs:simpleContent>
```

```

    <xs:extension base="xs:string"/>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="unitString_t">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="units" type="xs:string"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="revision_t">
  <xs:sequence>
    <xs:element name="timestamp" type="xs:dateTime" minOccurs="0"/>
    <xs:element name="generator" type="generator_t" minOccurs="0"/>
    <xs:element name="annotation" type="textAnnotation_t" minOccurs="0"/>
  </xs:sequence>
  <xs:attribute name="ID" type="xs:string"/>
</xs:complexType>
<xs:complexType name="orderedString_t">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="order" type="xs:string"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="value_t">
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="units" type="xs:string"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:simpleType name="valueTypes_t">
  <xs:restriction base="xs:string">
    <xs:enumeration value="float"/>
    <xs:enumeration value="boolean"/>
    <xs:enumeration value="varchar"/>
    <xs:enumeration value="integer"/>
    <xs:enumeration value="URI"/>
  </xs:restriction>
</xs:simpleType>
<xs:complexType name="catalogEntry_t">
  <xs:sequence>
    <xs:element name="metadataList" type="metadataList_t" minOccurs="0"/>
  </xs:sequence>
  <xs:attributeGroup ref="levelRef_ag"/>
  <xs:attributeGroup ref="ID_name_description"/>
</xs:complexType>
<xs:complexType name="analysisRef_t">
  <xs:attributeGroup ref="levelRef_ag"/>
</xs:complexType>
<xs:simpleType name="laterality_t">
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<xs:simpleType name="tissueType_t">
  <xs:restriction base="xs:string"/>
</xs:simpleType>
<!--***** Provenance types *****-->
<xs:complexType name="processStep_t">
  <xs:sequence>
    <xs:element name="package" type="versionedEntity_t" minOccurs="0">
      <xs:annotation>
        <xs:documentation>Software package that contains the program</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="program" type="versionedEntity_t">
      <xs:annotation>

```

```

        <xs:documentation>Software executable to was run in this step
      </xs:documentation>
    </xs:annotation>
  </xs:element>
  <xs:element name="programInvocation" type="mixedType_t">
    <xs:annotation>
      <xs:documentation>Exact command line text used to run the
        executable</xs:documentation>
    </xs:annotation>
  </xs:element>
  <xs:element name="timeStamp" type="mixedType_t"/>
  <xs:element name="cvs" type="mixedType_t" minOccurs="0"/>
  <xs:element name="user" type="mixedType_t" minOccurs="0"/>
  <xs:element name="machine" type="mixedType_t" minOccurs="0"/>
  <xs:element name="platform" type="versionedEntity_t" minOccurs="0"/>
  <xs:element name="compiler" type="versionedEntity_t" minOccurs="0"/>
  <xs:element name="library" type="versionedEntity_t" minOccurs="0"
maxOccurs="unbounded"/>
</xs:sequence>
</xs:complexType>
<xs:complexType name="provenance_t">
  <xs:annotation>
    <xs:documentation>Note: sourceData should be included along with application
parameters
    and configuration values</xs:documentation>
  </xs:annotation>
  <xs:sequence>
    <xs:element name="processStep" type="processStep_t" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="ID" type="xs:string">
    <xs:annotation>
      <xs:documentation>Optional identifier indicating the </xs:documentation>
    </xs:annotation>
  </xs:attribute>
</xs:complexType>
<!--***** Resource types *****-->
<xs:complexType name="informationResource_t">
  <xs:complexContent>
    <xs:extension base="resource_t"/>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="dcResource_t">
  <xs:complexContent>
    <xs:extension base="resource_t">
      <xs:sequence>
        <xs:element name="title" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="creator" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="subject" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="description" type="xs:string" minOccurs="0"
maxOccurs="unbounded"/>
        <xs:element name="publisher" type="xs:string" minOccurs="0"
maxOccurs="unbounded"/>
        <xs:element name="contributor" type="orderedString_t" minOccurs="0"
maxOccurs="unbounded"/>
        <xs:element name="date" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="type" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="format" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="identifier" type="xs:string" minOccurs="0"
maxOccurs="unbounded"/>
        <xs:element name="source" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="language" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="relation" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="coverage" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="rights" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>

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```
</xs:complexType>
<xs:complexType name="dataResource_t">
  <xs:complexContent>
    <xs:extension base="resource_t">
      <xs:sequence>
        <xs:element name="provenance" type="provenance_t" minOccurs="0"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="binaryDataResource_t">
  <xs:annotation>
    <xs:documentation>The parent type (abstract_resource_t) can describe a stream of
data.
  The extensions in this derived type (binaryDataResource_t) tell you that this data
  stream is composed of a sequence of units of a given data type and byte order. If
  the </xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="dataResource_t">
      <xs:sequence>
        <xs:element name="elementType" minOccurs="0">
          <xs:annotation>
            <xs:documentation>This element describes the type of individual data
            elements in the data record. For numeric data types, this indicates
            whether the element type is a signed integer ("int"), unsigned
            integer ("uint"), or floating-point ("float"), as well as the number
            of bits allocated to each element.</xs:documentation>
          </xs:annotation>
          <xs:simpleType>
            <xs:restriction base="xs:string">
              <xs:enumeration value="int8"/>
              <xs:enumeration value="uint8"/>
              <xs:enumeration value="int16"/>
              <xs:enumeration value="uint16"/>
              <xs:enumeration value="int32"/>
              <xs:enumeration value="uint32"/>
              <xs:enumeration value="int64"/>
              <xs:enumeration value="uint64"/>
              <xs:enumeration value="float32"/>
              <xs:enumeration value="float64"/>
              <xs:enumeration value="ascii"/>
            </xs:restriction>
          </xs:simpleType>
        </xs:element>
        <xs:element name="byteOrder" minOccurs="0">
          <xs:annotation>
            <xs:documentation>This element describes whether the individual data
            elements in the data record are stored with the
            most-significant-byte first (msbfirst) or least-significant-byte
            first (lsbfirst). This element is required if the the data type
            given by the "elementType" element has a size larger than one
            byte.</xs:documentation>
          </xs:annotation>
          <xs:simpleType>
            <xs:restriction base="xs:string">
              <xs:enumeration value="lsbfirst"/>
              <xs:enumeration value="msbfirst"/>
            </xs:restriction>
          </xs:simpleType>
        </xs:element>
        <xs:element name="compression" type="xs:string" minOccurs="0">
          <xs:annotation>
            <xs:documentation>If this element is present, the files pointed to by
            the uri elements are compressed data files. The only compression
            method specifically named by this specification is "gzip". As a
            special case for binaryDataResource_t and derived types, files
```

```
        compressed with gzip and containing a .gz suffix can be referenced
        in the uri element without the suffix. If a file pointed to by the
        URI does not exist, the application should search for the same file
        with the .gz suffix appended -- if it exists, use that file and act
        as if the compression element had been specified with the value
        "gzip". This allows the referenced files to be compressed or
        uncompressed at will (as long as the .gz suffix is appropriately
        added/removed from the filename), without needing to change the
        URI's in this element.</xs:documentation>
    </xs:annotation>
</xs:element>
</xs:sequence>
</xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="dimensionedBinaryDataResource_t">
  <xs:annotation>
    <xs:documentation xml:lang="en">This type adds multi-dimensionality to the
    (uni-dimensional) data stream represented by
    binaryDataResource_t.</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="binaryDataResource_t">
      <xs:sequence>
        <xs:element name="dimension" type="binaryDataDimension_t" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="mappedBinaryDataResource_t">
  <xs:annotation>
    <xs:documentation xml:lang="en">This type places the multi-dimensional data array
    (say a
    3-dimensional cube) into a coordinate space (say MR scanner
    coordinates).</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="binaryDataResource_t">
      <xs:sequence>
        <xs:element name="dimension" type="mappedBinaryDataDimension_t"
        maxOccurs="unbounded"/>
        <xs:element name="originCoords" type="xs:string" minOccurs="0">
          <xs:annotation>
            <xs:documentation xml:lang="en">This is a coordinate tuple giving the
            location of the first item in the data. For example, if this is an
            MR volume, this could be a triple giving the location in RAS
            coordinates of the first voxel in the data.</xs:documentation>
          </xs:annotation>
        </xs:element>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="binaryDataDimension_t">
  <xs:annotation>
    <xs:documentation xml:lang="en">This element stores information about one of the N
    dimensions in the data record. Multiple instances of this element are ordered from
    fastest-moving to slowest-moving. These elements provide information to describe
    the
    size (in data elements) of the N-dimensional bounding box for the data, and in some
    cases to describe the mapping of indexes within this bounding box to 'real-world'
    coordinates.</xs:documentation>
  </xs:annotation>
  <xs:sequence>
    <xs:element name="size" type="xs:int">
      <xs:annotation>
        <xs:documentation xml:lang="en">The number of elements in the data along one
```

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        traversal of this dimension.</xs:documentation>
      </xs:annotation>
    </xs:element>
  </xs:sequence>
  <xs:attribute name="label" type="xs:string">
    <xs:annotation>
      <xs:documentation xml:lang="en">This is a label for the dimension. The first three
        spatial dimensions (or however many exist) must be labeled, in order, 'x', 'y',
        and 'z'. The first temporal dimension must be labeled 't'.</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="splitRank" type="xs:string">
    <xs:annotation>
      <xs:documentation>If this attribute exists, this dimension is a "split" dimension,
        and this dimension must be "merged" with one or more other dimensions (with the
        same label) before presenting the data to the application. This is useful, for
        example, if the data is stored in Siemens' Mosaic DICOM format, where slices of
        a 3-D volume are arranged to look like they are tiled onto a square 2-D area. In
        this case, what would normally be called the 'z' dimension has two forks, one
        that occurs before the 'y' dimension (the first row in the data covers the first
        row of several slices), and one that occurs after the 'y' dimension. If, as in
        this case, there are two or more dimensions that should be merged into one, both
        component dimensions should have the label 'z', but have splitRank attributes
        "1" and "2", which specifies the order in which all 'split' dimensions of the
        same label will be merged. After merging, the resultant 'z' dimension element
        should contain the same children of the highest-ranked split 'z' dimension,
        except for the 'size' element, which will be the product of the sizes of all 'z'
        split dimensions. The position of the resultant dimension should be the position
        of the highest-ranked 'z' split dimension. The data itself should also be
        reordered to reflect the new dimension structure.</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="outputSelect" type="xs:string">
    <xs:annotation>
      <xs:documentation xml:lang="en">In the same way that the 'splitRank' attribute
        allows you to specify dimensions that should be merged before presenting the
        data to an application, this attribute specifies a data filter along this
        dimension. If this attribute exists, it should contain a whitespace-separated
        list of indices (indexed starting at 0). Only data points along this dimension
        that occur in the index list should be presented to the application. Likewise,
        the 'size' of the dimension, after selection, should be updated to reflect the
        new size of this dimension (which should be the number of indices in the content
        of this attribute).</xs:documentation>
    </xs:annotation>
  </xs:attribute>
</xs:complexType>
<xs:complexType name="mappedBinaryDataDimension_t">
  <xs:complexContent>
    <xs:extension base="binaryDataDimension_t">
      <xs:sequence>
        <xs:element name="origin" type="xs:float" minOccurs="0">
          <xs:annotation>
            <xs:documentation xml:lang="en">A value assigned to the first data
              element along this dimension. For example, if this dimension
              corresponds to "time", this element could store the time
              corresponding to the first data element. If this is a
              two-dimensional projection of the surface of the Earth, and this
              dimension takes you around the Earth parallel to the equator, this
              value could be the degrees longitude. For MRI data, this is the
              single coordinate on the Left-to-Right, Posterior-to-Anterior, or
              Inferior-to-Superior axis to which this dimension most closely
              matches (see 'direction' element and 'rasOrigin' element in
              'mrImageDataResource_t').</xs:documentation>
          </xs:annotation>
        </xs:element>
        <xs:element name="spacing" type="xs:float" minOccurs="0">
          <xs:annotation>
```



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<xs:documentation xml:lang="en">This is the average distance between
consecutive data elements in this dimension. If the spacing is not
regular, then it may be possible to calculate the actual distance
between any two data elements in this dimension using the
'datapoints' element.</xs:documentation>
</xs:annotation>
</xs:element>
<xs:element name="gap" type="xs:float" minOccurs="0">
  <xs:annotation>
    <xs:documentation xml:lang="en">This is the length of the unsampled
    space between consecutive data elements in this dimension, i.e. the
    distance between the end of one data element and the beginning of
    the next. For MRI data, this can be used to specify the gap between
    two collected slices &#x02015; the actual width of each slice
    can be calculated as 'spacing' minus 'gap'.</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="datapoints" minOccurs="0">
  <xs:annotation>
    <xs:documentation xml:lang="en">The content of this element is either
    (1) a whitespace-separated list of values, or (2) a list of 'value'
    elements, that can be used as a label for each data point along this
    dimension. The values can be numbers representing points on an axis
    (this is the typical case), text strings, coordinate tuples, etc.
    Any datapoint label that includes whitespace (coordinate tuples
    included) must be encapsulated within a child 'value' element. If
    this element is missing, it is assumed that labels can be calculated
    using information in other fields (such as 'origin', 'spacing',
    etc.). This element is particularly useful for dimensions with
    irregular spacing.</xs:documentation>
  </xs:annotation>
  <xs:complexType mixed="true">
    <xs:sequence>
      <xs:element name="value" type="xs:string" minOccurs="0" maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element name="direction" type="listoffloats_t" minOccurs="0">
  <xs:annotation>
    <xs:documentation xml:lang="en">This element contains a vector
    (represented as a whitespace-separated list of floating-point values
    in the appropriate coordinate system) that is parallel to this
    dimension's edge of the bounding box. The vector starts at the first
    element in the data and points towards subsequent elements along
    this dimension. For MRI data, this should be a unit vector in
    (R,A,S) coordinates (positive values are Right, Anterior, or
    Superior respectively) &#x02015; for 'x' and 'y' dimensions,
    this corresponds to the two vectors in the ImagePatientOrientation
    field in DICOM.</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="units" type="xs:string" minOccurs="0">
  <xs:annotation>
    <xs:documentation xml:lang="en">This stores the units used for all
    numeric values in this dimension element. In MRI data, this should
    be 'mm' for all spatial dimensions ('x', 'y', 'z') and 'ms' for the
    temporal dimension 't'.</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="measurementframe" minOccurs="0">
  <xs:annotation>
    <xs:documentation xml:lang="en">The mapping (if any) between the values
    expressed in &lt;datapoints&gt; and the coordinate system
    used by this datarec. For example, in DTI data, this is useful for
    mapping gradient direction vectors to the RAS coordinate space used
    in the &lt;direction&gt; vectors.</xs:documentation>
  </xs:annotation>
```

```
<xs:complexType>
  <xs:sequence>
    <xs:element name="vector" type="listoffloats_t" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
</xs:element>
</xs:sequence>
</xs:extension>
</xs:complexContent>
</xs:complexType>
<xs:complexType name="frag_uri_t">
  <xs:annotation>
    <xs:documentation>The external data pointed to by this uri is a "fragment", where a
      "fragment" is defined as a stream of data contiguously stored in the same file
      offset by 'offset' bytes and of 'size' bytes.</xs:documentation>
  </xs:annotation>
  <xs:simpleContent>
    <xs:extension base="xs:anyURI">
      <xs:attribute name="offset" type="xs:unsignedLong">
        <xs:annotation>
          <xs:documentation>The data for this fragment will start at this byte
            position in the resource specified by the 'uri' element. If this
            attribute does not exist or is empty, it is assumed to be
            zero.</xs:documentation>
        </xs:annotation>
      </xs:attribute>
      <xs:attribute name="size" type="xs:unsignedLong">
        <xs:annotation>
          <xs:documentation>This specifies the size of this block (in bytes) in the
            resource specified by the 'uri' element. If this attribute does not
            exist or is empty, it is calculated using the dimension and elementtype
            element.</xs:documentation>
        </xs:annotation>
      </xs:attribute>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:simpleType name="listoffloats_t">
  <xs:list itemType="xs:float"/>
</xs:simpleType>
<xs:complexType name="format_t">
  <xs:annotation>
    <xs:documentation>Container for describing imaging formats and file name extensions
      (currently underimplemented)</xs:documentation>
  </xs:annotation>
  <xs:sequence>
    <xs:element name="description" type="xs:string" minOccurs="0"/>
    <xs:element name="documentationList" minOccurs="0">
      <xs:complexType>
        <xs:sequence>
          <xs:element name="documentation" type="informationResource_t" minOccurs="0"
maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:element name="extensionList" minOccurs="0">
      <xs:complexType>
        <xs:sequence>
          <xs:element name="extension" type="xs:string" minOccurs="0"
maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
  <xs:attribute name="name"/>
</xs:complexType>
```

```

<!--*****          Event types          *****-->
<xs:complexType name="events_t">
  <xs:complexContent>
    <xs:extension base="abstract_data_t">
      <xs:sequence>
        <xs:element name="params" type="eventParams_t" minOccurs="0"/>
        <xs:element name="event" type="event_t" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="description" type="xs:string" minOccurs="0"/>
        <xs:element name="annotation" type="textAnnotation_t" minOccurs="0"
maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<xs:complexType name="event_t">
  <xs:annotation>
    <xs:documentation>This element represents an interval of time, with arbitrary
metadata
  (in the value element).</xs:documentation>
  </xs:annotation>
  <xs:sequence>
    <xs:element name="onset" type="xs:float" minOccurs="0"/>
    <xs:element name="duration" type="xs:float" minOccurs="0"/>
    <xs:element name="value" type="eventValue_t" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="annotation" type="textAnnotation_t" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="type" type="xs:string" use="optional"/>
  <xs:attribute name="units" type="xs:string" use="optional">
    <xs:annotation>
      <xs:documentation>This attribute is optional, but an group using this schema should
      agree on, use, and enforce measurement units consistently, to avoid the need for
      unit conversion in an application.</xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="name" type="xs:string" use="optional"/>
</xs:complexType>
<xs:complexType name="eventValue_t">
  <xs:annotation>
    <xs:documentation>User-specified metadata associated with an
event.</xs:documentation>
  </xs:annotation>
  <xs:simpleContent>
    <xs:extension base="xs:string">
      <xs:attribute name="name" type="xs:string"/>
      <xs:anyAttribute processContents="lax"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="eventParams_t">
  <xs:annotation>
    <xs:documentation>These value elements apply to all events in the parent event
list.</xs:documentation>
  </xs:annotation>
  <xs:sequence>
    <xs:element name="value" type="eventValue_t" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="abstract_tagged_entity_t">
  <xs:sequence>
    <xs:element name="metaFields" minOccurs="0">
      <xs:complexType>
        <xs:sequence minOccurs="0">
          <xs:element name="metaField" minOccurs="0" maxOccurs="unbounded">
            <xs:complexType>
              <xs:simpleContent>
                <xs:extension base="xs:string">

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```
        <xs:attribute name="name" type="xs:string"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:schema>
```