

Space-Time Coordinate Metadata: Status

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Scope

- Space–Time Coordinate metadata aim to provide a structure ensuring that intertwined coordinates are described:
 - Completely (no obvious defaults in the VO)
 - Self-consistently
- The coordinate frames involved:
 - Time
 - Space (position, velocity)
 - Spectral
 - Redshift/Doppler velocity

Model: STC Components

- Coordinate system contains a frame for each coordinate:
 - Reference frame (orientation)
 - Reference position (origin)
- Coordinates and properties:
 - Coordinate value, error, resolution, etc.
- Coordinate area:
 - The volume in coordinate space occupied by the data object that the metadata refer to

New Development

- Three areas of new development were prompted by discussions in Victoria:
 - Full implementation of specification of coordinate transformations
 - (Consequently) a revision of top-level derivation hierarchy – giving up some control, but leading to better consistency
 - Solar coordinate systems
- Special care was taken not to impact existing applications (Registry, VOEvent, Footprint service)

Multiple Coordinate Systems

- There may be multiple equivalent representations for the same data, e.g.:
 - Equatorial
 - Galactic
 - Detector coordinates
 - Pixel coordinates
- These are related through transformations
 - Transformations are now fully included in the coordinate system (reference frame and reference position) specification
 - Code to execute the transformations was to be implemented by David Berry (Starlink AST library)

Transformations

- Translation/origin:
 - Reference position
- Scaling and rotation:
 - Reference frame
 - Scale and rotate or rotation matrix (FITS WCS)
 - Projection – spherical (*tan*, *sin*, ...), *log*, *exp*, *lin*,...
- Reference pixel:
 - For pixel coordinates only

Transformations: Caveat

- Coordinate values in multiple systems
 - Make sure the transformations are correct
- Regions in multiple systems
 - Correct coordinate values
 - Small circles between spherical systems
 - Great circles are straight lines in *tan* projection, but not in any other
 - Small circles are awful even in *tan* projection
 - Want to be safe? Regions in one system only

Inheritance

- The top-level types are now all derived consistently by extension, rather than restriction
 - CoordSys contains one or more generic CoordFrames
 - PixelCoordSys contains, in addition, PixelFrame(s)
 - AstroCoordSystem contains, in addition to optional generic Frames, optional TimeFrame, SpaceFrame, SpectralFrame, RedshiftFrame
 - Should PixelFrame also be allowed?

Status

- Documents
 - I am working on WD/PR
 - Jonathan published first version of his note
- Schema issues
 - Should PixelFrames be allowed in AstroCoordSystem?
 - Use of Regions in non-spatial 2-D frames (Generic and Pixel)

<http://hea-www.cfa.harvard.edu/~arots/nvometa/v1.30/>



Schema Versioning

- Current version numbering: $V_{i.jk}$
- Suggest that:
 - Applications always refer to $V_{i.j}$
 - $V_{i.jk}$ always be downward compatible for all values of k
 - At IVOA site $V_{i.j}$ always point to the highest numbered $V_{i.jk}$

Finis



Applications

- Resource Profile
 - What's covered by this resource and what are the properties?
- Observation Description
 - Location of the observatory, as well as the coordinate volume occupied by the data
- Search Location
 - Specification of a query
- Catalog Entry Location
 - Coverage of a set of catalog entries

- Additional slides from Victoria, May 2006



XML Developments: Summary

- Single schema
- Referencing model for IVOA
 - Allowing use of template components that are referred to by name, as well as referencing within a document
- Accommodate code generators
 - Java, C#, C++
- Support for:
 - VOEvent
 - Footprint service
 - Registry (coverage)
 - SED, generic coordinates
 - ADQL

Model and Schema Design

- For now:
<http://hea-www.cfa.harvard.edu/~arots/nvometa/v1.30/>
- STC Model
- STC schema
 - Schema documentation
 - List of changes
- XML examples
- STC clients may (and do) decide to implement a subset of capabilities

Schema Development

- Single schema:
 - The three schemata (stc:, crd:, reg:) have been consolidated into a single schema stc: this allows use of default namespace
- Referencing
 - Referencing standards were developed based on Xlink, rather than XInclude; this leaves it up to the client to decide what to do with a reference
 - Flexible multi-level internal and external referencing

Referencing

- Base type with 4 optional attributes:
 - id (ID)
 - idref (IDREF)
 - xlink:type="simple"
 - xlink:href (anyURI)
- Precedence:
 - body
 - idref
 - xlink:href
- Xlink leaves the interpretation up to the application, action to the client
- STC document specifies href to be an XPath pointer to an element that may be substituted

Xlink Reference Example

- Choose coordinate system from library:

```
<stc:AstroCoordSystem id="MyCoordSys"  
  xlink:href="ivo://STCLib/CoordSys#UTC-ICRS-TOPO"  
  xlink:type="simple"/>
```

- More sensible (but not guaranteed) use of id:
(id is the tag that connects coordinates to a system)

```
<stc:AstroCoordSystem id="UTC-ICRS-TOPO"  
  xlink:href="ivo://STCLib/CoordSys#UTC-ICRS-TOPO"  
  xlink:type="simple"/>
```

Support Developments

- VOEvent
 - Use of STC for WhereWhen resulted in changes in the way multi-dimensional coordinates are expressed
 - Added support for orbital parameters
- Footprint/Region web services (Budavari)
 - Redesigned certain parts of the inheritance scheme to support code generators (.net, JAXB)
 - Added support for curves & region difference

VOEvent WhereWhen

```
<WhereWhen>
  <ObsDataLocation xmlns="http://www.ivoa.net/xml/STC/stc-v1.30.xsd">
    <ObservatoryLocation id="KPNO" xlink:type="simple"
      xlink:href="ivo://STCLib/Observatories#KPNO"/>
    <ObservationLocation>
      <AstroCoordSystem id="FK5-UTC-TOPO" xlink:type="simple"
        xlink:href="ivo://STCLib/CoordSys#TT-ICRS-TOPO"/>
      <AstroCoords coord_system_id="FK5-UTC-TOPO">
        <Time unit="s">
          <TimeInstant>
            <ISOTime>2005-04-15T23:59:59</ISOTime>
          </TimeInstant>
          <Error>1.0</Error>
        </Time>
        <Position2D unit="deg">
          <Value2>
            <C1>148.88821</C1>
            <C2>69.06529</C2>
          </Value2>
          <Error2Radius>0.03</Error2Radius>
        </Position2D>
      </AstroCoords>
    </ObservationLocation>
  </ObsDataLocation>
</WhereWhen>
```

VOEvent Restrictions

- STC usage limited to a dozen coordinate systems:
 - Time: UTC, TT, TDB
 - Position: FK5, ICRS; solar under consideration
 - Reference position: topocenter, geocenter, barycenter
- Observatory locations:
 - Library of participating observatories
 - Generic locations (LEO, GSO, earth neighborhood)

Footprint Region Example

- `<?xml version="1.0" encoding="utf-8"?>`
- `<MyRegion xsi:type="STCRegion"`
- `xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"`
- `xmlns="http://www.ivoa.net/xml/STC/stc-v1.30.xsd"`
- `xmlns:xlink="http://www.w3.org/1999/xlink">`
- `<AstroCoordSystem xlink:type="simple"`
- `xlink:href="ivo://STCLib/CoordSys#UTC-FK5-TOPO"`
- `id="UTC-FK5-TOPO"/>`
- `<Circle coord_system_id="UTC-FK5-TOPO">`
- `<Center unit="deg">`
- `<C1>333.81711620673087</C1>`
- `<C2>55.83295907051123</C2>`
- `</Center>`
- `<Radius>166.70368880492589</Radius>`
- `</Circle>`
- `</MyRegion>`

More Support Development

- SED
 - STC provides coverage and coordinate system support for SED, partly through reference mechanism
 - In the process, support for generic coordinate axes was improved
 - UCD referencing was added
- Registry
 - Coverage
- ADQL
 - Region

Status and Plans

- Status:
 - Schema version 1.30 has been published
 - Works with JHU region web service
 - Incorporated in VOEvent, Registry, SED draft
- Plans:
 - Update Proposed Recommendation and resubmit
 - Sort out solar coordinate systems
 - Develop standard components Xlink library
 - Develop STC Java library

Status Summary (1)

- The schema has been finished and is at:
<http://www.ivoa.net/xml/STC/stc-v1.30.xsd>
- Xlink is at:
<http://www.ivoa.net/xml/Xlink/xlink.xsd>
- The full 493–page document is available from
<http://hea-www.harvard.edu/~arots/nvometa/v1.30/>
- Generated code for Java, C++, and C# is available at the same site
- Examples are also available from this site; they have been validated
- The schema supports full referencing, UCDs, and generic coordinates

Status Summary (2)

- STC has been incorporated into VOEvent after extensive finetuning
- STC has been incorporated in Tamas's footprint service (regions)
- STC has been incorporated into the spectral DM
- STC specification has been submitted for incorporation into ADQL

Status Summary (3)

- I am currently working on the revision of the document:
 - XML schema will become part of the PR
 - New support features need to be documented
 - Examples need to be updated
 - Reference libraries need to be documented
 - A how-to section needs to be added, similar to the one in VOEvent
 - I am willing to provide a style sheet for display of STC metadata
 - Solar coordinate systems need to be sorted out; this will be handled through a simple extension of the schema

Summary of Changes (1)

- A new referencing mechanism, Xlink, that is robust and flexible; in case of ambiguities, the precedence is:
 - 1. Content of the element
 - 2. Content of element referred to by IDREF attribute
 - 3. Content referenced by Xlink attributes
 - 4. UNKNOWN
- Any element that is either missing or which content cannot be determined is assumed to be UNKNOWN, in which case it is up to the client to either reject the document or choose a suitable default.
- Replacing Lists of doubles (i.e., arrays, particularly in multi-dimensional – spatial – coordinate axes) by explicit enumeration of the individual components.
- Allowing units to be specified at all levels of coordinates (i.e., also at the leaves).

Summary of Changes (2)

- Simplified version of error circles in 2-D and 3-D
- Name optional in Coordinate elements, Timescale optional in astronTimeType
- Rename Region Shape "Constraint" to "Halfspace".
- Add "Difference" to Region operations (redundant but practical).
- Optional epoch attribute; precedence:
 - 1. Epoch provided in coordinate leaf element
 - 2. Epoch provided in higher coordinate node
 - 3. Time of observation
 - 4. Equinox of, or implied by, coordinate system
 - 5. UNKNOWN
 - Note that under most circumstances, where an observing time is provided, epoch is not needed.

Summary of Changes (3)

- Allow position to be specified by orbital elements.
- Allow definition of a position path (curve).
- Removed all anonymous types.
- Added application-specific types (in particular for footprint service).
- Consolidated everything in one schema.
- Added basic support for generic coordinates.
- Added an optional UCD attribute to the basic STC attribute group.