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"Geospatial Information for a Smarter Life and Environmental Resilience"
Towards an Implementable Data Schema for 4D/5D Cadastre Including Bi-Temporal Support

Rod Thompson (Australia)
Peter van Oosterom (Netherlands)
(Presenter) Sudarshan Karki (Australia)
Key points

• Cadastral boundaries are physical or legal
• Cadastral records are different “instances in time”
• Important to have history of cadastre (bounds and transactions)
• Important to maintain history of database and real world events
• Professionals wish to see planning cadastre
• Bi-Temporal schema created based on LADM classes
• Implement 2D/3D/4D in existing or new databases – fit for purpose
Legal boundary with variable physical location
Legal rights, Physical missing – no issues

This fiat boundary is legally enforceable, but is not a physical object in the real world.
Legal and Physical Boundaries of a 3D Object

Footprint of volume in cadastral plan

Real world construction

Isometric view in cadastral plan
Point “Movements” – Database Events (DBEvent)

- The point may be legal, may or may “not there” to measure (e.g. volumes)
- The position may be improved – without the point moving (e.g. coordinate corrections, positional accuracy upgrade)
- The position may be found to be incorrect, and then fixed (both DBEvent and RW)
- Ground movements (e.g. earthquake, tectonic plate – may be both DBEvent and Real-world event);
- Datum changes – (Changes in coordinates – DBEvent, does not affect point)

A change of point coordinates can not be assumed to indicate a real-world boundary change
Point “Movements” – Real-world events

- Boundaries created (e.g. Subdivisions - both Real-world and DBEvent – Chronologically flexible)
- Error fix - Boundary position may be altered (Real-world event, may be DBEvent)
- Resurvey – Positional improvement (May be both Real-world and DBEvent)
- Infrastructure, Buildings etc. – (may create more RW points, will create DBEvent)

A change in Real-world points will more likely be reflected as a Database event
Proposed “planning cadastre”

Future topology may be incompatible

- As time passes, alternatives are dropped
- Tentative proposals do not become real data unless actioned in some way
Bi-Temporal Package

- Versioned object is bi-temporal
- Database history
- Real-world history
- Record of when a valid event is entered into the database

C4 = Cadastral 4th Dimension

**C4_DB_Event**
- eventID: int
- eventDate: DateTime
- eventType: String
- responsiblePartyID: int

**C4_Valid_Event**
- acceptance: DateTime
- sID: Oid

**C4_VersionedObject**
- creatingDBEventID: int
- destroyingDBEventID: int
- creatingSID: int
- destroyingSID: int

**LA_SpatialSource**
- +lifeSpanEventID
- +eventID
- +creatingDBEventID
- +destroyingDBEventID
- +creatingSID
- +destroyingSID
Bi-Temporal History

- It is important to know what has happened in the past – where subdivision activity has been strong, who has owned the land, what its value was, etc.
- We want this to be as accurate as possible, and if we find inaccuracies or errors, we would like to fix them.

- It is also important to know what our knowledge of the cadastre was in the past, e.g. if a decision was made that now seems irrational, we want to know what information was available at the time leading up to that decision.
- This sort of history should not be “corrected” (it is an audit trail).
Bi-Temporal Data

- **Real World** – Physical parcels, Buildings, Fences, Infrastructure, Marks
- **Activities** – Subdivision, Position movement, Build etc.

- **Database** – Record Parcel descriptions, Other Attributes.
- **Activities** – Record real-world transactions, database transactions etc.
Spatial units and their geometry
Point in 2D and 3D

- A 2D point is a “pole” from $-\infty$ to $+\infty$
- A 3D point is a Z value on that pole
- A corner is on the boundary of a spatial unit
- A control point is an identified 2D point

C4_VersionedObject
  C4_Point2D
    + pID: int
    + lat: long
    + long: long
    + estimatedAccuracy: DQ_AbsoluteExternalPositionalAccuracy
    + productionMethod: LA_Lineage
    + transAndResult: LA_Transformation

C4_VersionedObject
  C4_Point3D
    + pointSuffix: AlphaString
    + z: int

C4_VersionedObject
  C4_ControlPoint
    + controlPointID: String
    + z: int
    + monumentation: LA_MonumentationType

C4_VersionedObject
  C4_Corner
    + seqNr: int
    + pID: int
    + pointSuffix: AlphaString
    + interpolationRole: LA_interpolationType
Face String / Tall Face

- LADM FaceString – a collection of tall faces
Tall Face, Face and Vertical Face

- Tall Face – an extrusion of a 2D line segment from $-\infty$ to $\infty$
- Face – any finite surface patch in 3D
- Vertical Face – a Face that lies within a Tall Face
Spatial Units

- 2D Spatial Units are defined by an ordered collection of tall faces. This is equivalent to a polygon, but defines a 3D prism of space.
- 3D Spatial Units are also bounded by an ordered collection of tall faces. This defines the 2D “footprint” of the spatial unit.
- In addition, a set of faces limit the volume within the prism defined by the footprint.
- Faces may be shared.
- Vertical faces might not be stored.

```
C4_VersionedObject
LA_SpatialUnit

C4_SpatialUnit
+ referencePoint: C4_Point2D
+ referencePointZ: int

::LA_SpatialUnit
+ area: LA_AreaValue
+ dimension: LA_DimensionType
+ extAddressID: Oid
+ label: String
+ referencePoint: GM_Point
+ suID: Oid
+ surfaceRelation: LA_SurfaceRelationType
+ volume: LA_VolumeValue

C4_VersionedObject
C4_SpatialUnitFace
+ reversed_fl: boolean

C4_VersionedObject
C4_TallFace
+ faceID: int

C4_VersionedObject
C4_Face
+ faceID: int

C4_VersionedObject
C4_VerticalFace
+ pID_from pID_to
```
Temporal Aspects

- All the major tables inherited from Versioned Object
- The database is bi-temporal in nature.
Simple Subdivision Example

Real-world change
Subdivision with Data Improvement

- In 1966 control point placed
- In 1970 SU1 created
- In 2000 database loaded
- In Aug 2018, survey for subdivision
- In Sep 2018, subdivision entered into DB

A. The 2000 database knowledge for 1970
B. Current database knowledge of 1970 situation
C. The database knowledge for Aug 2018
D. Current database knowledge
Conclusions

- A fit-for-purpose schema has been proposed which supports 3D spatial units and temporal history in the same database as 2D spatial units.
- The schema is bi-temporal in nature, and includes the “Valid date” and “Database Event” time-stamping.
- The proposed schema supports the “Tentative Time” approach for the inclusion of development proposals.
- The various “time events” can be queried from the database.
• Rod Thompson: rodnmaria@gmail.com
• Peter van Oosterom: P.J.M.vanOosterom@tudelft.nl
• Sudarshan Karki: Sudarshan.Karki@dnrme.qld.gov.au