Big Data Analytics WG: Use Case Array Databases

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Structural Variety in Big Data

- Stock trading: 1-D sequences (i.e., arrays)
- Social networks: large, homogeneous graphs
- Ontologies: small, heterogeneous graphs
- Climate modelling: 4D/5D arrays
- Satellite imagery: 2D/3D arrays (+irregularity)
- Genome: long string arrays
- Particle physics: sets of events
- Bio taxonomies: hierarchies (such as XML)
- Documents: key/value stores = sets of unique identifiers + whatever
- etc.
Arrays in [Geo] Science & Engineering

- spatio-temporal sensor, image, simulation, statistics data(cubes)
rasdaman: Agile Array Analytics

- "raster data manager": SQL + n-D raster objects
  
  ```sql
  select img.green[x0:x1,y0:y1] > 130
  from LandsatArchive as img
  where avg_cells( img.nir ) < 17
  ```

- Scalable parallel "tile streaming" architecture

- In operational use
  - OGC Web Coverage Service
  - Core Reference Implementation
Inset: Hadoop is not the Answer to All

- no builtin knowledge about structured data types
  - “Since it was not originally designed to leverage the structure [...] its performance [...] is therefore suboptimal” [Daniel Abadi]
- M. Stonebraker (XLDB 2012): „will hit a scalability wall“
Adaptive Tiling

- Sample tiling strategies [Furtado]:
  - regular
  - directional
  - area of interest

- rasdaman storage layout language

```sql
insert into MyCollection
values ...
  tiling area of interest [0:20,0:40], [45:80,80:85]
  tile size 1000000
  index d_index storage array compression zlib
```
Sample Application: Database Visualization

```sql
select
code(
    struct {
        red: (char) s.image.b7[x0:x1,x0:x1],
        green: (char) s.image.b5[x0:x1,x0:x1],
        blue: (char) s.image.b0[x0:x1,x0:x1],
        alpha: (char) scale( d.elev, 20 )
    },
    "image/png"
)
from SatImage as s, DEM as d
```

[JacobsU, Fraunhofer; data courtesy]
Use Case: Plymouth Marine Laboratory

- “Avg chlorophyll concentration for given area & time period, from x/y/t cube”
  - 10, 60, 120, 240 days

- Conclusions:
  - “we must minimise data transfer as well as [client] processing”
  - “standards such as WCPS provide the greatest benefit”
Secured Archive Integration

First-ever direct, ad-hoc mix from protected NASA & ESA services in OGC WCS/WCPS Web client (EarthServer + CobWeb)
Parallel / Distributed Query Processing

- 1 query → 1,000+ cloud nodes

```sql
select
    max((A.nir - A.red) / (A.nir + A.red))
- max((B.nir - B.red) / (B.nir + B.red))
- max((C.nir - C.red) / (C.nir + C.red))
- max((D.nir - D.red) / (D.nir + D.red))
from A, B, C, D
```
Array Databases: Practice Proven with rasdaman

- from simple data access to agile analytics
  - strictly based on open OGC Big Geo Data standards
- 130+ TB databases, 2D, 3D x/y/z & x/y/t, 4D x/y/z/t timeseries
- single query distributed to 1,000+ cloud nodes
OGC WCPS

- **OGC Web Coverage Processing Service (WCPS)**
  - high-level geo raster query language; adopted 2008

- WCPS 2: all grid types:

- "From MODIS scenes M1, M2, M3: difference between red & nir, as TIFF"
  - ...but only those where nir exceeds 127 somewhere

```plaintext
for $c$ in ( M1, M2, M3 )
  where some( $c$.nir > 127 )
return encode( $c$.red - $c$.nir, "image/tiff" )
```
Recent Progress: ISO Array SQL

- ISO 9075 Part 15: SQL/MDA
  - resolved by ISO SQL WG in June 2014

- n-D arrays as attributes

```
create table LandsatScenes(
    id: integer not null, acquired: date,
    scene: row( band1: integer, ..., band7: integer ) array [ 0:4999,0:4999]
)
```

- declarative array operations

```
select id, encode(scene.band1-scene.band2)/(scene.nband1+scene.band2), "image/tiff"
from LandsatScenes
where acquired between "1990-06-01" and "1990-06-30" and
  avg( scene.band3-scene.band4)/(scene.band3+scene.band4)) > 0
```