Beyond Rasters: Introducing The New OGC Web Coverage Service 2.0

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- **International, multi-cultural**
  - 1,300+ students, 101 nations, 75% non-German
  - English official language on campus

- **Smart Systems Computer Science Graduate Program**
  - AI, machine learning, robotics, databases, Web services, distributed systems, graphics, visualization, ...

- **Large-Scale Scientific Information Systems research group**
  - focus: large-scale n-D raster services and beyond
  - theory, practice, application, standardization
  - www.jacobs-university.de/lsis
Facing the Data Tsunami

“sensor” feeds

coverage server

Picture stolen from SWE
Taming the Data Tsunami

Picture stolen from SWE
Introduction

- Open GeoSpatial Consortium (OGC, www.opengeospatial.org) drives geo service standards
  - In collaboration with ISO, W3C, OASIS Open, ...

- Coverage = n-D "space-time-varying phenomenon" [ISO 19123, OGC AT6]
  - coverage: space, time → value set

- Web Coverage Service (WCS): access to coverages & subsets thereof
  - deliver data suitable for further processing
  - Suite of core + extensions, scalable in functionality
WCS 2.0 Design Goals

- **Model extension**
  - GML harmonization & unifying, service independent coverage model
  - Increased domain support: web mapping, EO, atmospheric & ocean research, geology, aviation, aerosol chemistry, sensor coverage data, …
  - Beyond raster: curvi-linear grids, more general meshes, …
  - N-D coverages
  - But: coherent with ISO 19123

- **Engineering aspects**
  - Separate data model from service model
  - Concise semantics
  - Improved testability
  - Core/extension modularization
  - Crisp & easy to handle for implementers
  - Allow for efficient & scalable implementations
Coverage Definition

From SWE Common

From GML 3.2.1

«Data Type»

AbstractFeature

AbstractCoverage

+ coverageFunction: gml:CoverageFunction [0..1]
+ metaData [0..1]

«Union»

DomainSet

DataRecordPT

RangeSet

«Data Type»

«Data Type»

«Union»

From SWE Common

«Data Type»

«Data Type»

«Data Type»

«Data Type»
Coverage Subtypes

Discrete Coverage

- MultiSolid Coverage
- MultiSurface Coverage
- MultiCurve Coverage

Abstract Coverage

- MultiPoint Coverage

Continuous Coverage

- Rectified GridCoverage
- Referenceable GridCoverage

as per GML 3.2.1
WCS Core Service Model: Data

WCS offering can be seen as a single virtual document

Hook for future service-related coverage metadata
WCS Core Service Model: Ops

- **GetCapabilities**  
  What service extensions? What coverages?

- **DescribeCoverage**  
  coverage metadata

- **GetCoverage**  
  coverage, or subset thereof

- …now concisely defined as pruning from coverage offerings
WCS Core Functionality

In Core, simple data access (more in extension packages):

\[ \text{subset} = \text{trim} \mid \text{slice} \]
Use Case: Satellite Time Series

[DFD-DLR, Diederich et al, 2001]
Web Coverage Processing Service

- OGC WCPS standard = aka “XQuery for multi-dimensional coverages”
  - Bridges WCS & WPS
  - Ex:
    
    ```
    for $c$ in ( Modis1, Modis2, Modis3 ), $m$ in ( MyMask )
    where
      avg( $c$.red * $m$ ) > 127
    return
      encode( $c$.red / $c$.nir, "tiff" )
    ```

- Function nesting → unlimited complexity, formal algebraic semantics
- Expressive power: image & signal processing, statistics
WCPS Use Case Scenarios

ad-hoc navigation, extraction, aggregation, analytics:

- Time series

- Image processing

- Summary data
  - current value is \(2200\);  
  - average over all values up to now currently is \(7461.7692307692305\).

- Sensor fusion 
  & pattern mining
Outlook: Application Profiles

- = domain-oriented combination of extensions

- Under work: Earth Observation Application Profile
  - EO-specific focus: only 2-D gridded coverages
  - Core + at least these extensions:
    - Scaling & interpolation
    - EPSG CRSs
    - at least one of: GeoTIFF, NetCDF, JPEG2000
    - at least one of: Get/KVP, SOAP
  - Plus extra definitions: EO-specific metadata

- Further possible Application Profiles:
  - metocean
  - sensor
Reflection: Mission Accomplished?

- **Goals**
  - Crisp: 14 reqs coverage structure, 42 reqs core
  - Modular: achieved
  - Beyond raster: achieved conceptually, new coverage types need practical evaluation
  - Harmonization: GML, WCS ok; WPS, O&M/SWE under work
  - Formal semantics: partially

- **Challenges**
  - Underlying OWS Common allows many variants, difficult for clients
  - ...and is loose in metadata: can be a remote catalog, but structure undefined
  - How to model extensibility, yet remain type safe
Conclusion

- Coverages fundamental geo data structure
  - All earth science disciplines, large part of sensor data

- WCS 2.0 (adopted August 2010): beyond rasters, all GML coverage types
  - www.opengeospatial.org/standards/wcs

- NASA: WCPS as on-board interface for EO-1
  - satellite can answer ad-hoc raster queries

- See also:
  - Our group: www.jacobs-university.de/lsis
  - Our n-D raster server: www.rasdaman.org
  - WCS 2.0 demo at www.earthlook.org