A Provenance Data Model for astronomy

ADASS XXVI, 19th October 2016, Trieste

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What is provenance?

- In general: tracking the history, origin of something:
  - art
  - food industry
  - information (data vis) on news webpage
  - scientific data!
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- In astronomy: explain how data sets were produced:
  - Who created the data?
  - Which algorithm was used to produce it?
  - Which steps were undertaken to process the image?
  - Can I get access to the original, uncalibrated files from the observation?
Goals for IVOA Provenance Data Model

- For a given data set, provenance should help to ...
  - Discover steps of production
    Aid in reprocessing: Which processing steps have been done already?
  - Give attribution
    Who was involved in the project? Who can I ask about these data?
  - Allow to assess the quality of the data
    Is the dataset suited for my research?
  - Aid in debugging
    Find possible error sources, e.g. check version of processing software, ambient conditions, telescope configuration, parameter settings, ...
  - Search in structured provenance metadata
    Includes „forward tracking“: which datasets were produced with the same pipeline version, follow scientific productivity of instruments/telescopes or software usage
Example in astronomy

- Where is the data coming from?
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=> Track data back in time
Example in astronomy

- identify data entities

Diagram:

- Observation
  - Raw images
    - Calibration
      - Calibrated files
        - Pipeline
          - Data release
Example in astronomy

- identify data entities
- identify processes (activities)
Example in astronomy

- identify data entities
- identify processes (activities)
- identify responsible people

- data release
- pipeline
- calibrated files
- calibration
- raw images
- observation

Project XXX
Software developer
Observer
Example in astronomy

- identify data entities
- identify processes (activities)
- identify responsible people

- provenance is defined by the relations between data, activities and the people/projects involved

Diagram:
- Observation → Raw Images → Calibration
- Calibration → Calibrated Files → Pipeline
- Pipeline → Data Release → Project XXX
- Software developer
- Observer
- Time
Examples for core objects

- **Entities (datasets):**
  images, catalogs, database tables, spectra, log files, parameters, ...

- **Activities:**
  observations; processing steps like bias subtraction, image stacking, continuum fit, object extraction; simulations, ...

- **Persons/Organizations:**
  creator, publisher, developer, ...
Provenance DM core classes

- same core classes as in W3C ProvDM model:
  - http://www.w3.org/TR/prov-dm/, published 2013

- 3 core classes:
  - Activity
  - Entity
  - Agent

- core relations:
  - used
  - wasGeneratedBy
  - wasAttributedTo
  - wasAssociatedWith

![Diagram of core classes and relations]
Extending the core

- in astronomy: know most common processes
- introduce new “description” classes for common processes and datatypes:

  - Activity => Experiment in Simulation Data Model
  - ActivityDescription => Protocol in Simulation Data Model
  - EntityDescription => Dataset in Dataset Data Model

- connection to similar structures in other data models:
Overview class diagram from working draft

Work in progress!
see Working Draft at http://wiki.ivoa.net/twiki/bin/view/IVOA/ObservationProvenanceDataModel

blue = core classes
yellow = additional classes
green = classes from other IVOA data models
grey = relation classes
Use case: RAVE

- multi-fibre spectroscopic survey
- radial velocities + derived stellar properties for ~ half million stars
- use provenance to track e.g.
  - Who was responsible for determining the log g values in DR5?
  - Which fibre observed the spectrum for star xyz?
  - Study selection effects using information on intended and actually observed stellar sample

see javascript example at https://escience.aip.de/prov/graphs/example.html
Use case: Pollux

Database of more than 8000 very high resolution synthetic spectra in optical domain (3000 Å - 12000 Å)

Software engineer: Michèle Sanguillon
Scientists: Ana Palacios, Agnès Lèbre
Use case: CTA

- see Poster by Mathieu Servillat: P5.5 (upstairs)
- must ensure that data processing can be traced and reproduced
- essential to inform users about processing steps
What's your use case?

- Would you benefit from a standardized solution to expose your provenance metadata?
  => contact us!
- How do you currently keep track of the data history?
- Which metadata would you need most?
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Talk to us and join discussions in IVOA data model working group!