SET TIMER
Introduce each other
"Hi, My name is..."

For the scope of the course on Metadata Representation Languages, we consider our collective as "SOL of Life"

The Problem(s)

- Available resources on Earth are limited
  - 2018 Shortage of Capacitor due to Supply of Resources vs Demand of Consumers
  - Raspberry Pi Shortage
- Domain of Space Data is large and complex across many sources

Brandon

Earth's Resources:

- Earth’s existing resources are becoming non-renewable or consumed at an accelerated rate
- The rich minerals on Earth remain a non-renewable resource for humans as they continue to refine the currently available resources to build products from everyday use items to hardware for technological advances.
- Due to the limited availability of rich minerals, humans will eventually need to branch out from Earth to other planetary bodies for mineral excavations.

Existing Tools:

- The available research and data can be cumbersome to navigate through.
- Specialized analyst are required to go out and make the various connections themselves from the numerous existing research and data.

The Solution

- SOL Of Life plans to support the missions of space excavation, exploration, and research
- The tool provides a querying solution without the need of a specialist
- Possible Users:
  - Government Entities
  - Researchers
  - Analysts
  - Space Research Institutions
  - Space Enthusiasts

Ryan
SOL Of Life plans to support the missions of space exploration and research by providing a tool to query collected data of asteroids within Sol, our solar system. Users of our tool could range anywhere from government entities, researchers, analysts, other space research institutions, and space enthusiasts.

The available research and data can be cumbersome to navigate through. A knowledge graph is interesting in the case of mining in space because it is an uncharted frontier. There are so many questions that are difficult to answer surrounding the viability and cost. A knowledge graph would provide a method for answering those questions without the need for a specialized analyst to go out and make the various connections themselves from the existing research and data.

Data that includes celestial body mineralogy predicted from infrared readings combined with data of the body's trajectory path could be used together for humans to plan space missions in order to send out spacecrafts for mining expeditions

Limitations of SOL

- Limited to the Sol Solar System
- Data is estimated calculations which are only as accurate as the source
- Only contains data for Asteroids

Megan

- Data is limited by what is available and what we were able to find readily accessible
- Accuracy of data is based from estimated calculations
- Some of the data we utilize:
    - NASA and MP3C for Astronomic Orbital Measurements and Physical Property conclusion data from their respective infrared readings
    - Asterank for Economic Measurements (profitability and value) derive further from NASA's orbital and physical property data
    - The SkyLive for their available asteroid predictions for Distance From Earth
- SOL contains the existence of all reported NASA Asteroid; however, data is missing from the ontology's implementation

Usage of SOL's Ontology

1. What are the top 5 most frequently occurring minerals within 1.5 astronomical units from Earth in 2024?

2. What are the top 3 most occurring asteroid types within 1.5au from Earth in 2025?

3. Which is the closest asteroid to Earth in the next 24 months and when does that occur?

4. What are the 5 closest asteroids that may contain iron?

5. What are the 3 most potentially profitable asteroids within 0.75au of Earth in 2024?

6. When will 162173 Ryugu be within 1au of Earth?

7. How long will 162173 Ryugu be within 1au of Earth?

8. Based on current trajectory of 162173 Ryugu, how far from Earth will 162173 Ryugu be in 8 months?

9. How much time is available until the 162173 Ryugu is within 1au of Earth?

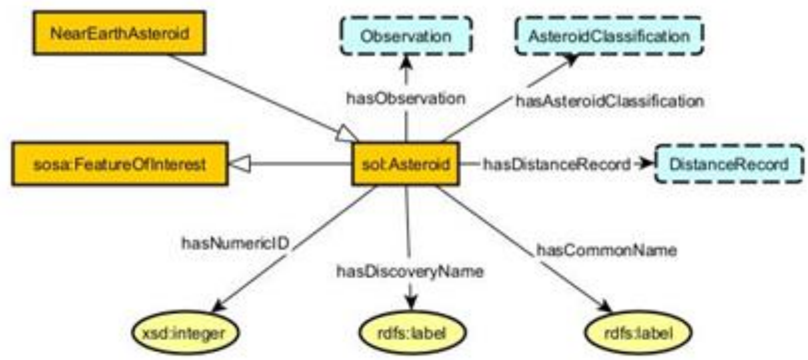
10. Which asteroid is the first to come within 0.5au of Earth that contains iron?

Megan

- Competency Questions relative to Exo-Mining
- Included are select questions that the SOL Team was interested in answering from the implemented ontology provided the available data of NASA, MP3C, and other sources.

Asteroid

- Source Pattern: SOSA's Feature of Interest
- Source Data: Asterank, MP3C, NASA_JPL

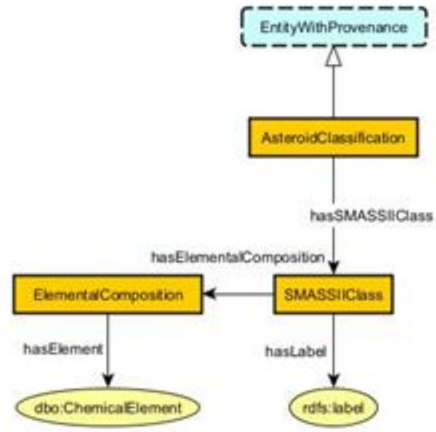


Megan

- Asteroids
    - What are asteroids?
        - The domain of space objects is broken up into three categories: Artificial Space Objects, Space Weather Phenomena, and Natural Space Objects
        - Asteroids exist as Natural Space Objects
    - An Asteroid consists of multiple properties, including naming standards and measurements.
    - SOL defines Asteroids based upon the SOSA Feature of Interest with respect to the Observation Pattern
    - An Asteroid is a Feature of Interest with at least 1 Observation, exactly 1 Classification, and 0 or more Distance Records
    - Asteroid's also have a variety of identifiers such as numeric ID, Discovery Name, and Common Name

Asteroid Classification

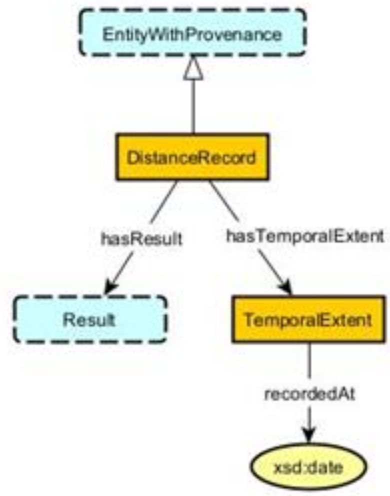
- Source Pattern: No Source Pattern
- Source Data: Asterank, Asteroid Spectral Types



Megan
- Asteroid Classification
    - An Asteroid's Classification can be used to derive the elemental composition of the Asteroid
    - The SMASSII classification is represented as a label
    - The derived elemental composition is stored as a Chemical Element, and can be composed of 1 or more elements
    - Classifications are EWP's, as every classification is determined by some authority

Distance Record

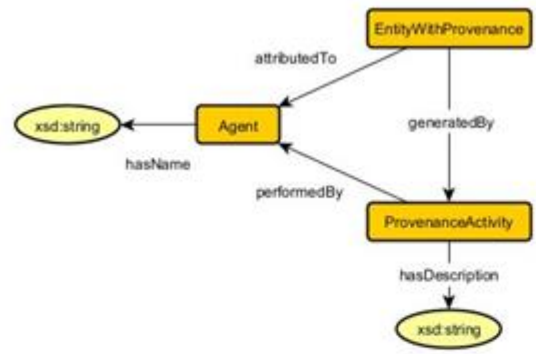
- Source Pattern: MODL's Record and Temporal Extent
- Source Data: SkyLive



Megan
- Distance Record
    - Having the ability to query an asteroid's distance from earth at a given time is important to the users of SOL
    - The record pattern allows this data to be represented as a union of a distance measurement (result) at a specific point in time (Temporal Extent)
    - Distance records are EWP's, as every distance being recorded is determined by some authority

Data as Entity With Provenance

- Source Pattern: MODL's Entity With Provenance
- Source Data: Asterank, MP3C, NASA_JPL, Skylive

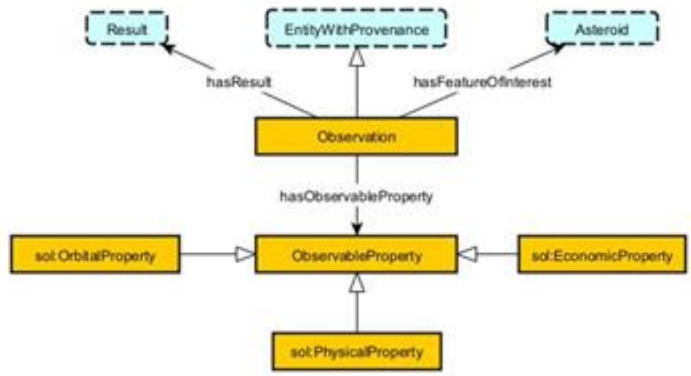


Ryan

- Entity With Provenance
  - All the properties of asteroids within SOL are gathered by some authority
  - The EWP relationship allows data to linked to and traced back to the authority that produced it
  - EWP also provides a description of how the data was produced, represented by ProvenanceActivity.

Observation

- Source Pattern: SOSA Observation
- Source Data: Asterank, MP3C, NASA_JPL



Ryan

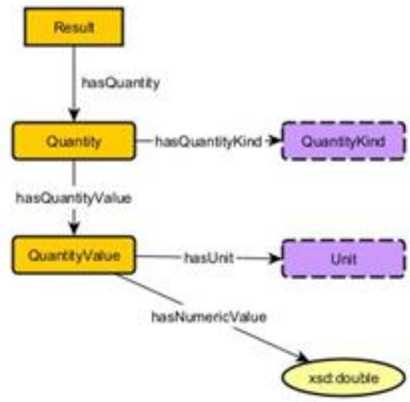
- Observation
    - SOL's Observation pattern is based on the SOSA Observation pattern
    - Observations represent asteroid properties and definitive characteristics that can be measured or calculated
    - SOL classifies observations into 3 categories, Orbital Property, Physical Property, and Economic Property
    - Each observation is an EWP, having a single source authority
    - Each observation relates to a single asteroid, represented by "hasFeatureOfInterest"
    - Each observation has a single result representing the numeric measurement or calculation associated with the given observation
    - Example: a ValueObservation is an EconomicProperty calculated by Asterank and is associated with a single asteroid and has a single result representing it's numeric value.

Data Results

- Source Pattern: MODL's Result and Quantity
- Source Data: Asterank, MP3C, NASA_JPL
- Select Axiom:

Result SubClassOf inverse (hasResult) exactly 1 (Observation or DistanceRecord)

Every Result belongs to exactly 1 Observation or DistanceRecord.



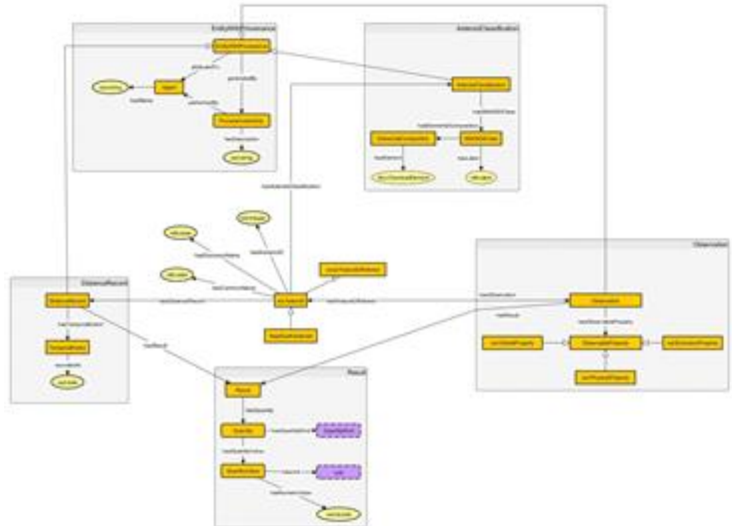
Ryan

- Result
  - SOL's Result pattern is modeled after MODL's Result and Quantity patterns
  - A result represents a quantifiable value related to the Asteroid.
  - A result has a Quantity
    - Quantity Kind: Description of what the result represents
    - Quantity Value: The measurement or calculation being represented
      - Unit: The unit associated with the measurement or calculation
      - Numeric Value: The actual numeric value associated with the quantity
  - Quantity Kind and Unit are controlled vocabularies
  - An interesting axiom we represent is:
    - Every Result belongs to exactly 1 Observation or Distance Record.

The Overall Knowledge Graph

Namespaces:

@base http://www.soloflife.org .
@prefix sol-ont: http://soloflife.org/lod/ontology/ .
@prefix sol-qk: http://soloflife.org/lod/quantitykinds.
@prefix sol-unit: http://soloflife.org/lod/units .
@prefix solr: http://soloflife.org/lod/resource/ .



Brandon

- Many of the relationships detailed through our schema diagram are represented as a one-to-one or one-to-many relationship; with selective one-to-none.
- Asides for the previously discussed Axiom of a Result being represented as either an Observation or a Distance record, the overall design did not have many large-concept/key notion-to-key notion specific axioms to consider.

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Group Talk

- Showcase Jena Fuseki Live Demo of Sparql Query
- **Competency Question #7:** "How long will 162173 Ryugu be within 1au of Earth?"
- **Bridged Datasets:** sbdb_jpl_asteroids_with_constraints.csv, Asteroid_Distances.csv
- **SPARQL Query:**

```
SELECT ?timeStart ?timeEnd ?duration
WHERE {
 {
  SELECT ?timeStart
  WHERE{
    ?asteroid sol-ont:hasCommonName ?name ;
       sol-ont:hasDistanceRecord ?record .
    ?record sol-ont:hasTemporalExtent ?te .
    ?te sol-ont:recordedAt ?timeStart .
    ?record sol-ont:hasResult ?r .
    ?r sol-ont:hasQuantity ?q .
    ?q sol-ont:hasQuantityValue ?qv .
    ?qv a sol-ont:QuantityValue;
    sol-ont:hasNumericValue ?distance;
    sol-ont:hasUnit ?unit .
    Filter(
      ?name="Ryugu"
```

```
        && ?distance < 1
      )
    }ORDERBY(?timeStart) LIMIT 1
  }
  .
  {
   SELECT ?timeEnd
   WHERE{
      ?asteroid sol-ont:hasCommonName ?name ;
            sol-ont:hasDistanceRecord ?record .
      ?record sol-ont:hasTemporalExtent ?te .
      ?te sol-ont:recordedAt ?timeEnd .
      ?record sol-ont:hasResult ?r .
      ?r sol-ont:hasQuantity ?q .
      ?q sol-ont:hasQuantityValue ?qv .
      ?qv a sol-ont:QuantityValue;
      sol-ont:hasNumericValue ?distance;
      sol-ont:hasUnit ?unit .
      Filter(
        ?name="Ryugu"
        && ?distance > 1
      )
    }
  }
  FILTER(?timeEnd>?timeStart)
  BIND((?timeEnd-?timeStart) as ?duration)
} LIMIT 1
```

Future Works

The astorb database at Lowell Observatory (October 2022) by N.A Moskovitz, et al.

- https://asteroid.lowell.edu/gui/

Tie together Albedo infrared readings alongside Asteroid Classification and Elemental Composition

Information Retrieval techniques to continuously pull in Distance Recordings for more implementation of other Asteroids

Brandon

- The usage of SOL's Ontology is very much hypothetical, and more of a proof-of-concept. It serves as a great starting point for space knowledge by not requiring the user's to jump between data sources.
- The Astorb DB, which was published in October 2022, was discovered by the SOL Team near the beginning of April. It contains similar data to what was provided by NASA and MP3C from a new Entity; however, rather than introducing this mid-production, this may be the start of adding more data to SOL's Ontology to discover more "interesting" facts on Asteroid.
    - Equally the astorb db relies on Tabular SQL design with Postgre; therefore, SOL could collaborate to transform the available data into KG
- Additionally, the SOL Ontology was only concerned with Asteroids; however, those are not the only celestial bodies that could be observed for material excavation. As listed in the schema diagram, a Near Earth Asteroid would have existed in SOL as an Asteroid less than 1au from Earth provided it's Spatio-Temporal Extent defined in a Distance Record.
- Albedo Infrared Readings is a big part of EWP's Activity for generating the specific data. Discussion with an Astronomer may lead to linking Infrared Results into the ontology which has the potential of connecting Asteroid Types (SMASSII Classification) without relying on the need of the data itself labeling the type.

Retrospective

Brandon's Feedback:

- What went well?

Re-introduction to set theory, lecture portion of Knowledge Engineering, Visualizing Data in a different realm (Graphs vs Tables), Group chosen topic research (for the midterm and final project), consistent availability of the instructor (even during off-hours)

- What could change?

Periods where the Group Implementation met with a hard-stop potentially could have been avoided with some supplemental assignments

- Fun: 4/5
- Usefulness: 3.5/5

Ryan's Feedback:

- What went well?
  The breakdown of deliverables for the project was well paced and each step built off the last well.
- What could change?
  The lecture material in the first half of the class gave a solid "Why", though could have given more "What and How".
- Fun: 3/5
- Usefulness: 4/5

Megan's Feedback:

- What went well?
  Structuring the course as a project was a great way to ensure that we have real experience building knowledge graphs.
- What could change?
  I personally would have benefitted from having lectures on Tuesdays and group work on Thursdays. It was a firehose of information in the beginning which could have been spread out over the course.
- Fun: 3/5
- Usefulness: 4.5/5

SUMMER
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THANKS

Q & A

Reference to the Databases

- Asterank: https://www.asterank.com/
- Asteroid Spectral Types https://en.wikipedia.org/wiki/Asteroid_spectral_types
- MP3C: https://mp3c.oca.eu/
- Nasa-JPL: SBDB: https://ssd.jpl.nasa.gov/tools/sbdb_query.html
- Sky Live: https://theskylive.com/