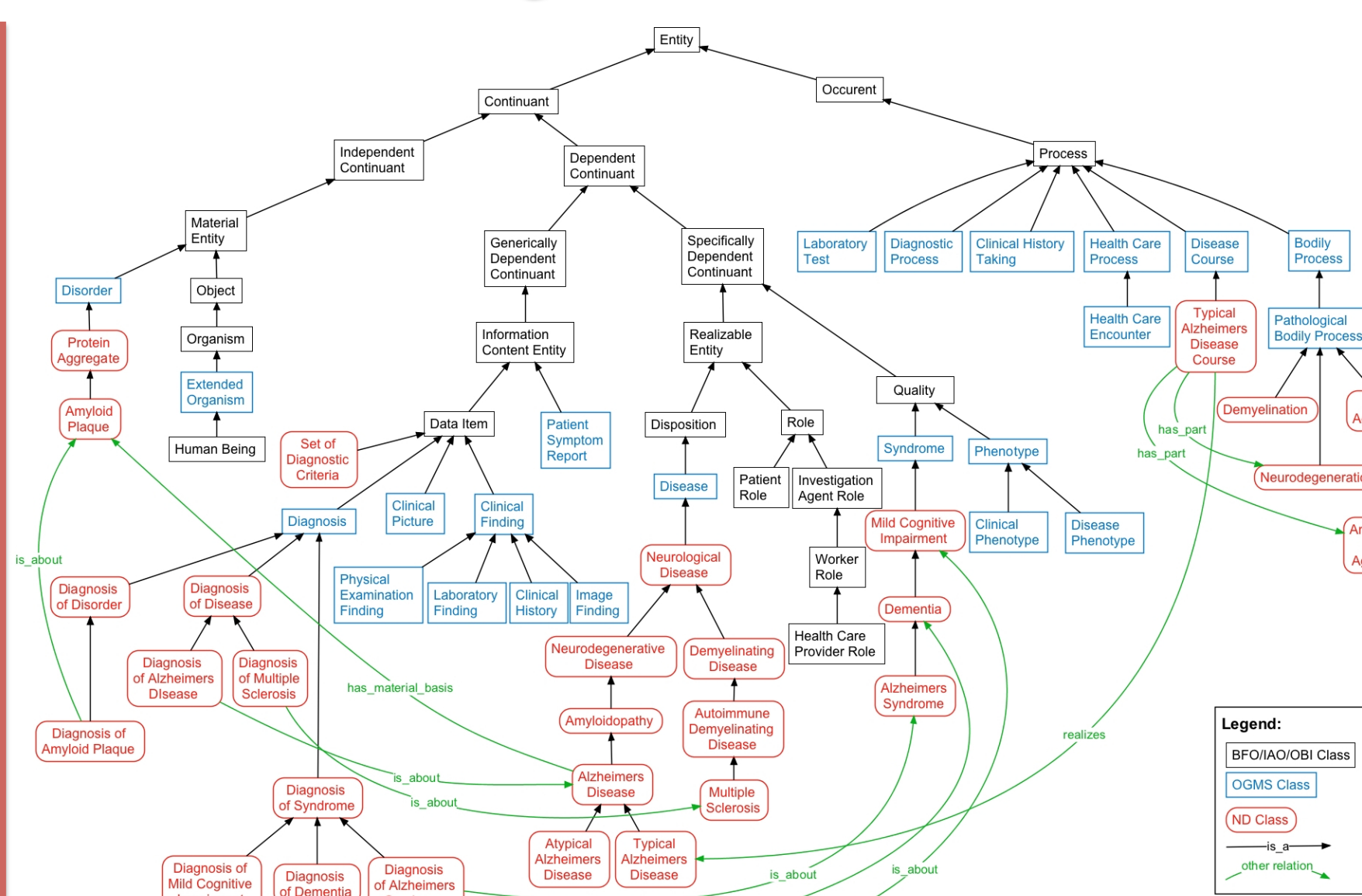


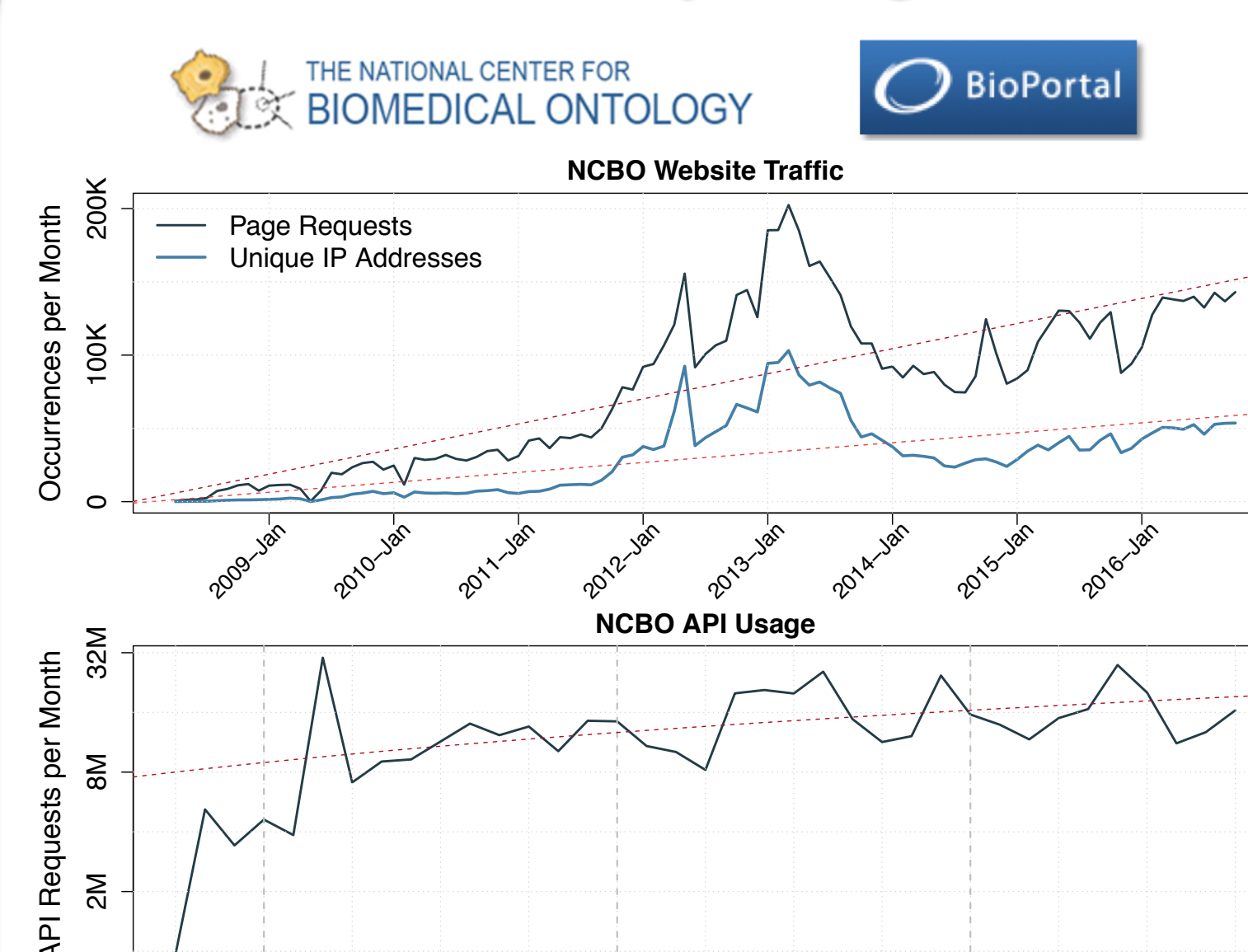
Biomedical Ontologies



Uses: Knowledge management, semantic search, data annotation, data integration.



Analyzing User Interactions: Motivation



- **Ontology Engineers:**
 - Identify exploration and querying patterns
 - Understand ontology usage and reuse
 - Prune unwanted classes and relations
 - Improve ontology content, in general
- **Biomedical Researchers:**
 - Identify temporal research trends
 - Identify frequently accessed classes
- **Ontology Repository Maintainers:**
 - Categorize user behaviors
 - Develop intelligent interfaces (predict future paths)
 - Provide targeted recommendations

Datasets & Methods

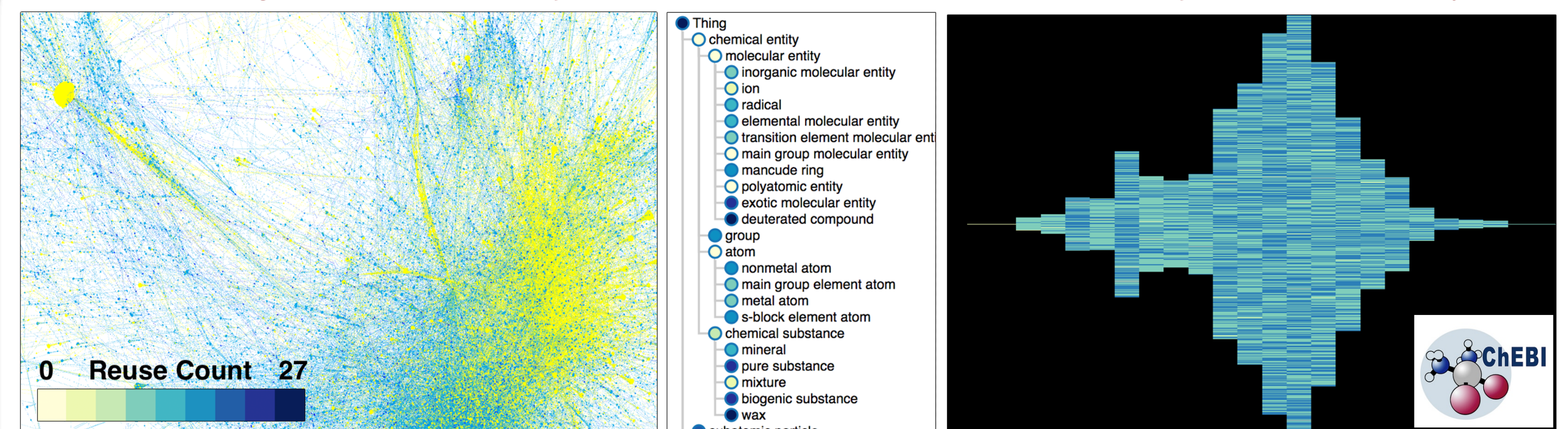
| Data Characteristics | Attributes |
|---|--|
| January 2015 version 115 Ontologies | <ul style="list-style-type: none"> Maximum Depth (from the root node/s) Siblings, Parents, Children, Class Labels |
| January 2013 - June 2016 WebUI: 5.4M Requests, 1M Users API: 67.2M Requests, 205K Users | <ul style="list-style-type: none"> WebUI Unique IP Requests (annual) API Unique IP Requests (annual) Set of classes browsed or queried by each user |
| January 2015 Reuse Data IRI and CUI Reuse | <ul style="list-style-type: none"> Number of ontologies reusing a class Set of classes reused by an ontology |
| Ontology Annotations NHGRI GWAS Catalog PubChem Database of Bio-Assays | <ul style="list-style-type: none"> Number of GWAS annotated by an EFO class Number of PubChem assays that use a compound annotated by a ChEBI class |

Methods embedded in a Web Application:

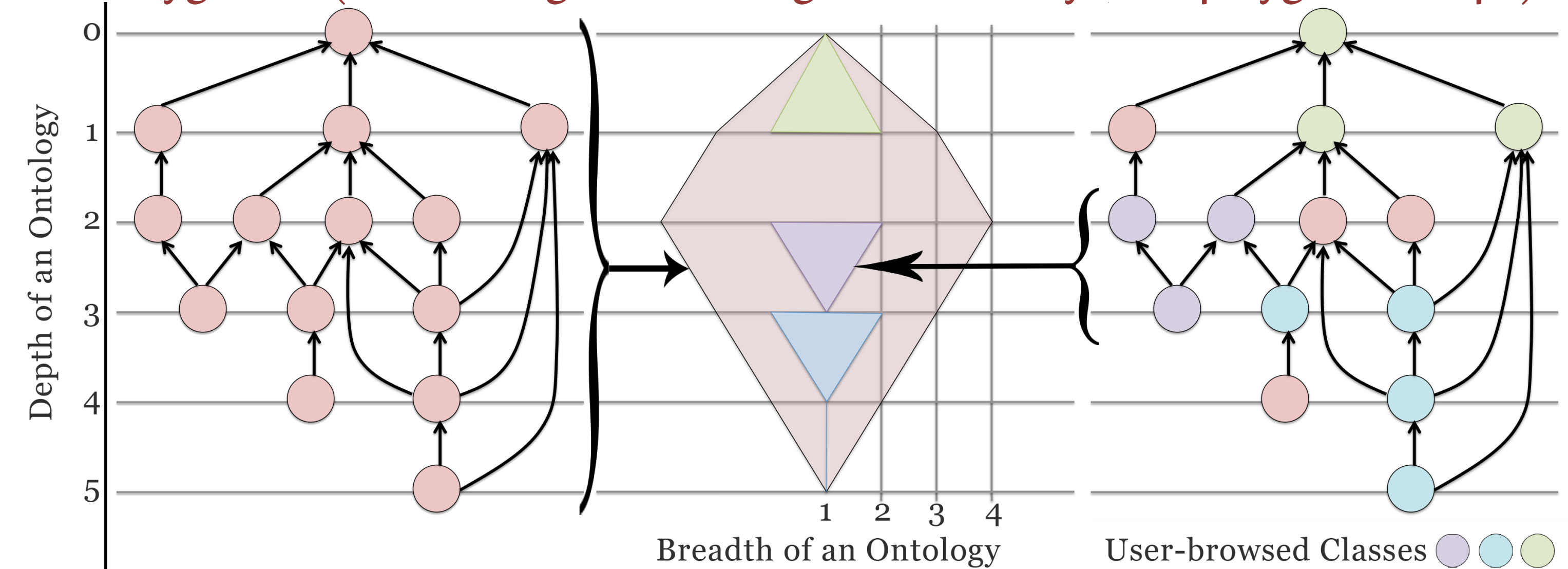
- ❖ Spearman Correlation and Jaccard Similarity for each ontology, for comparisons between WebUI Access, API Access, and Reuse attributes, and significance testing using ANOVA and Tukey HSD post-hoc tests.
- ❖ Fisher's Exact Test with FDR-adjusted p -values and odds ratio to determine significantly accessed classes in an ontology, during a particular time period or using a particular interface.

Visualization of Biomedical Ontologies

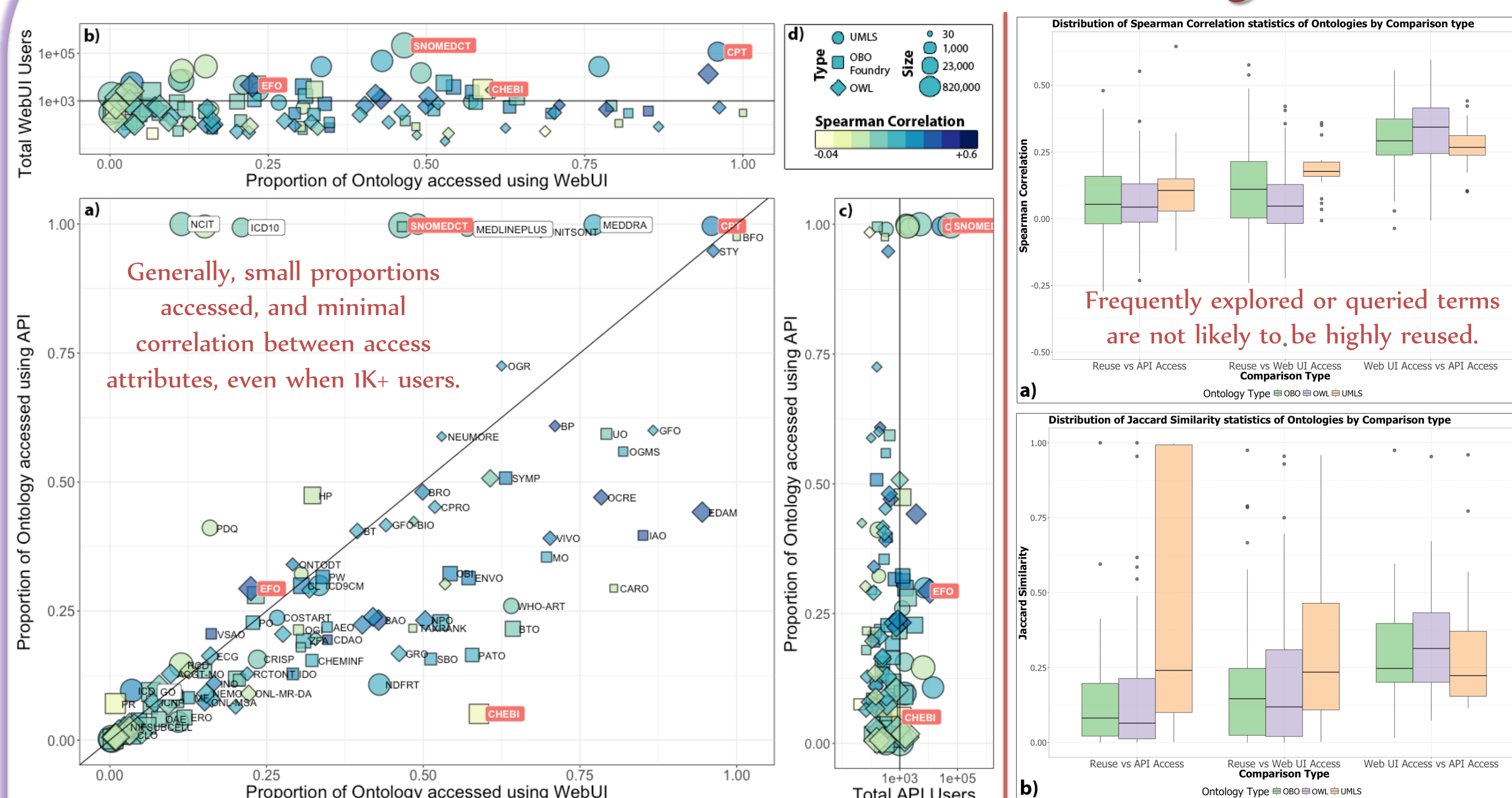
Existing methods: Graph-based, Indented Tree, and Implicit Hierarchy



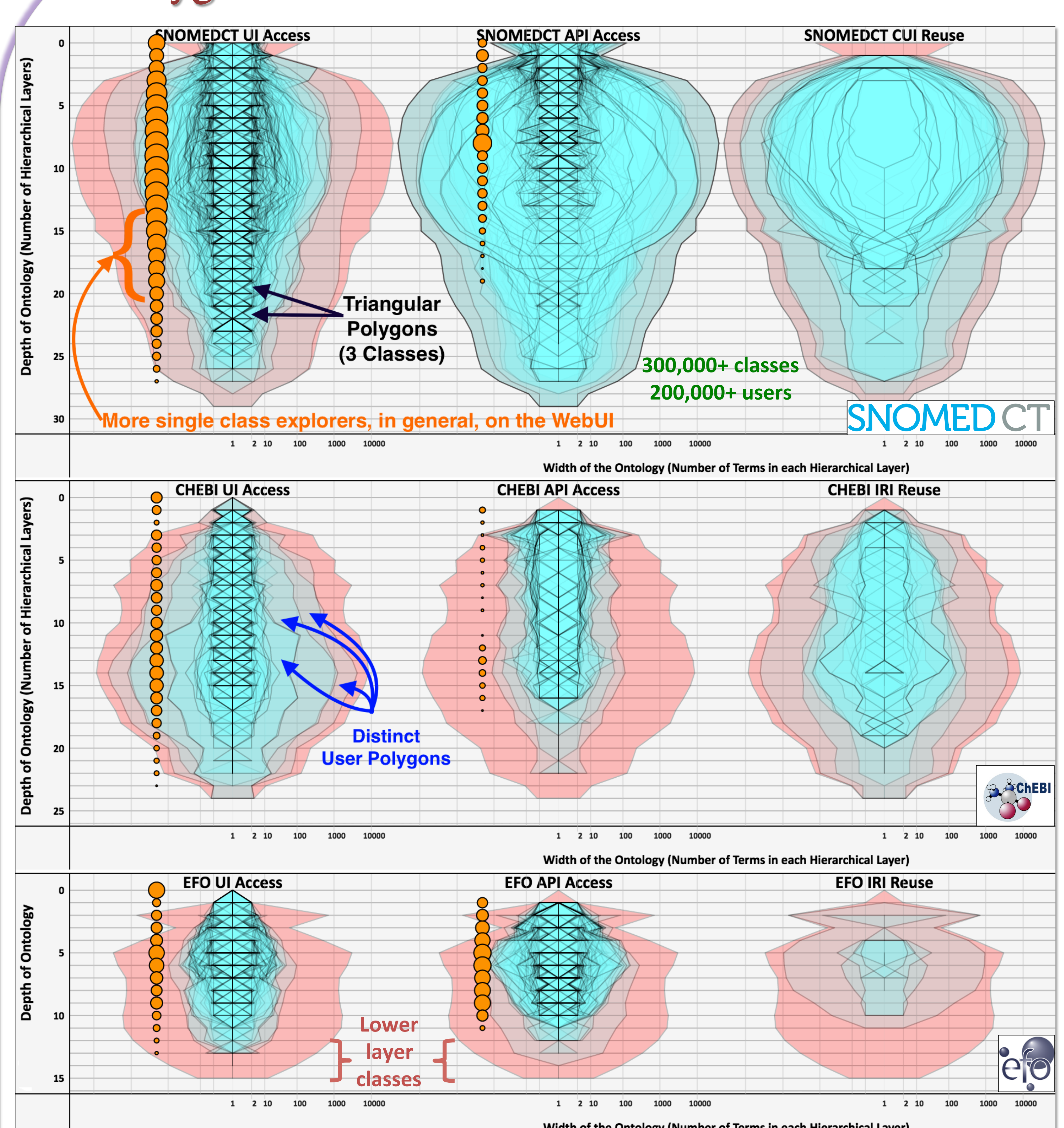
PolygOnto (Converting the ontological hierarchy to a polygonal shape)



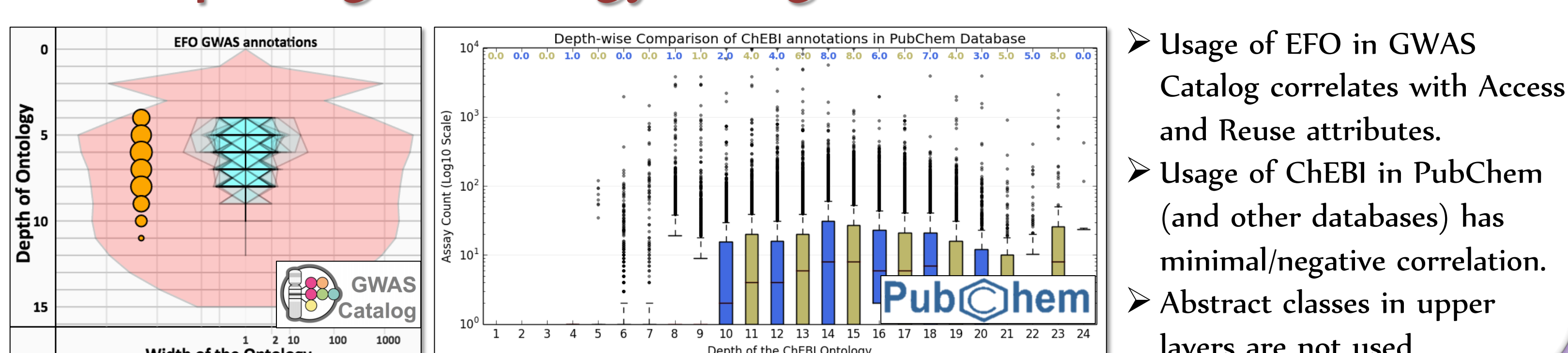
Statistics across Biomedical Ontologies



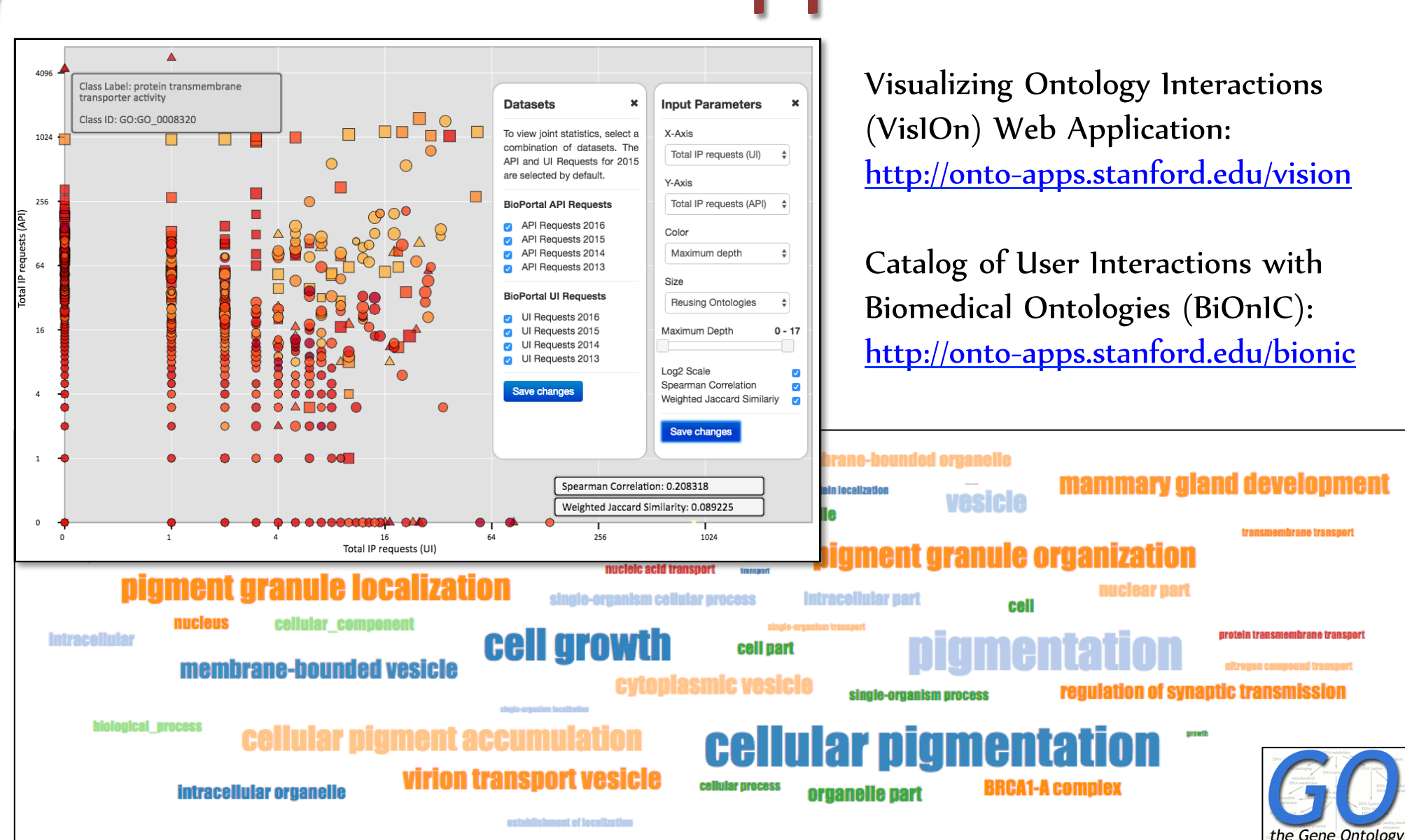
PolygOnto Visualizations for Access and Reuse



Comparing Ontology Usage with Access and Reuse



Web Application & Future Work



Few research directions:

- Evaluate usability of PolygOnto and VisOn for different stakeholders.
- Predict next user browsing paths based on user behaviors and ontology structural attributes.
- Understand influence of time and access mode on why certain classes are browsed or queried more.
- Research to improve ontology users' browsing and querying experience.

- Classes in the lower layers of ontological hierarchy are less explored, queried or reused.
- Triangles (1 Parent \rightarrow 2 Child classes) and Inverted Triangles (1 Child \rightarrow 2 Parents classes) patterns emerge.
- Generally, WebUI user explore more single classes or triangle-shaped patterns (Median = 3).