Graph database approach to management and use of SNOMED CT encoded clinical data

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Overview

- Employment of graph database technology for SNOMED CT in context of clinical use
- Result of SIA Schema Project:
  - Manage post-coordinated expressions for surgical pathology
- Results and additional findings
- Sample queries

Initial Use Case

- Instantiate a data base with numerous, real-time post-coordinated expressions of surgical pathology findings.

- Relational database designs resulted in HUGE join tables
  - Suggested a use case for a triple-store database (RDF?)

  - Investigation of NoSQL options suggested graphDB's

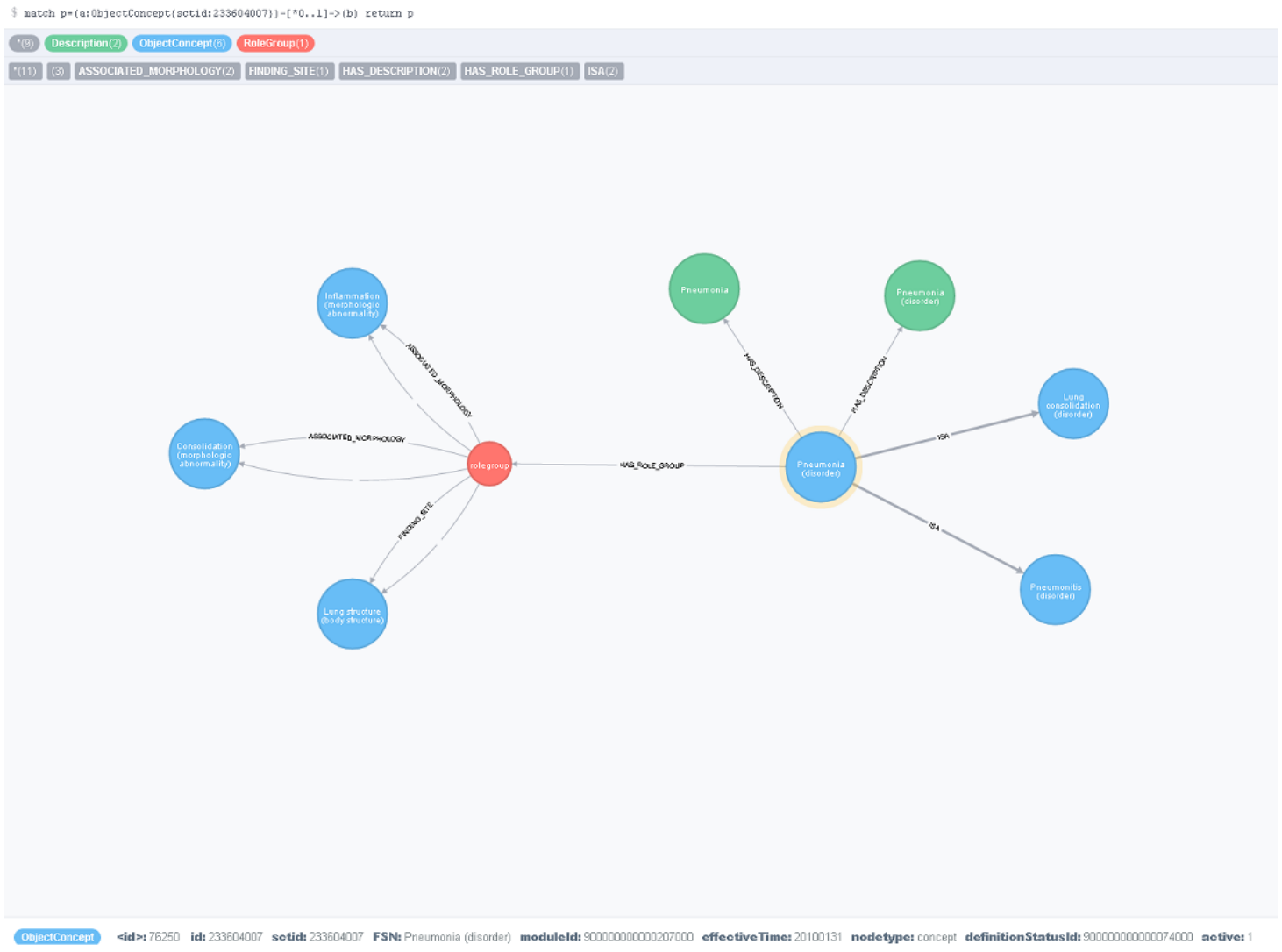
- Graph databases:
  - Class of NoSQL
  - Emphasize connectedness of data vs. rows/columns of data
  - Open world vs. closed world
    - Flexible
    - Transactionally ACID properties
  - SNOMED CT is a directed, acyclic graph

- Used Neo4j (San Mateo, CA), open sourced, java based

Approach

- Graphs consist of Nodes and Relationships (edges) that connect Nodes
  - Nodes and Edges can have properties (“Property Graph”)
- Used Snapshot, RF2 release of SNOMED CT International release (classified version)
- All SNOMED CT concepts represented as nodes
  - All RF2 metadata represented as properties of nodes
  - Active, module ID, definition status ID, effective time
- All SNOMED CT attributes represented as edges
  - RF2 Metadata as properties
- All names set as nodes with relationship to SNOMED CT expression node
- Result: A graph database with 100% of SNOMED CT content
- Fast! – Transitive Closure Calculation time < 60 sec on laptop

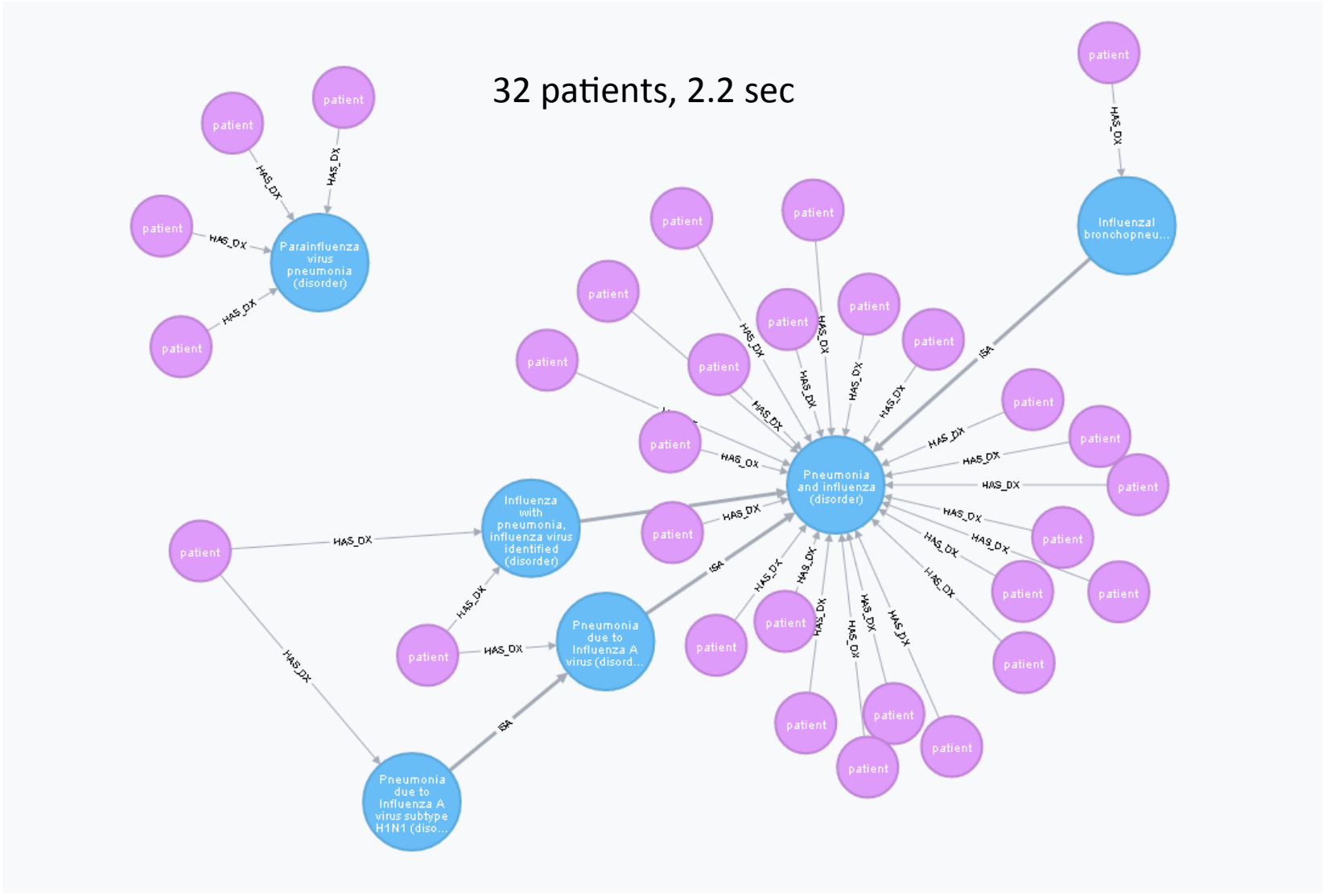
Example: Pneumonia



Add Patient Data

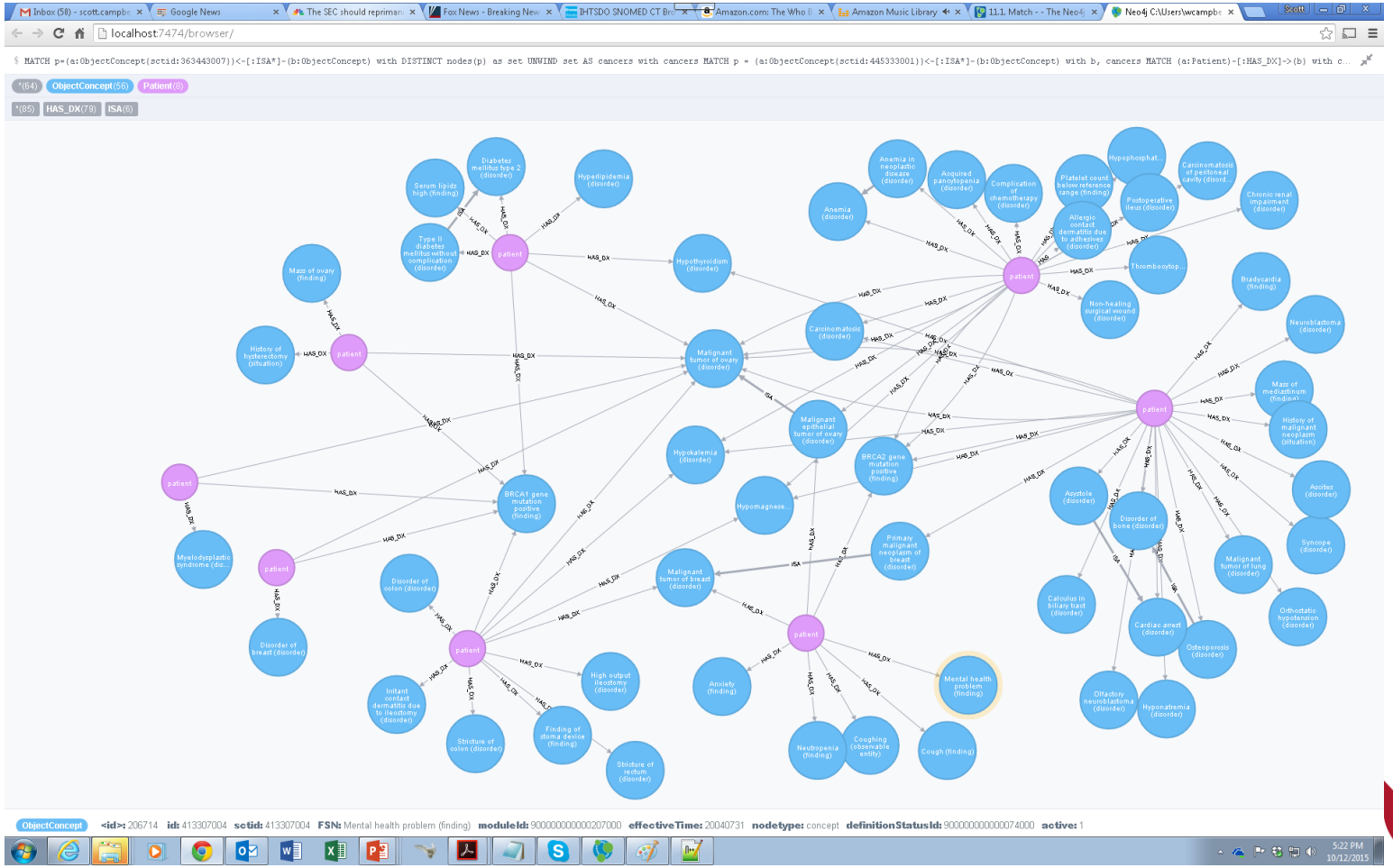
- Import patient records from de-identified clinical data warehouse
- Approximately 465,000 patients
- Import patient problem lists (All SNOMED CT encoded)
  - Up to 20 years of data
  - 2,770,000 diagnoses in total
  - Properties:
    - Date of diagnosis (start and end dates)
    - Active, inactive or deleted status
- Result
  - Patient identification by SNOMED CT codes/subsumption same as RDBMS based clinical data warehouse.
  - Queries were fast! Desktop on par with enterprise class server.
  - Unintended finding: Queries of negation, disjunction, depth

Example: Find all patients with Pneumonia due to some influenza virus or some parainfluenza virus



Queries of undefined depth

- Find all patients with positive BRCA1 or BRCA2 gene mutation who have an ovarian cancer diagnosis.
- Return all shared diagnoses.



How about Historicity?

- Graph database calculation of transitive closure table – FAST

- David Markwell's challenge
    - Can the database produce TC tables for multiple years AND a Delta TC table between and two release dates?

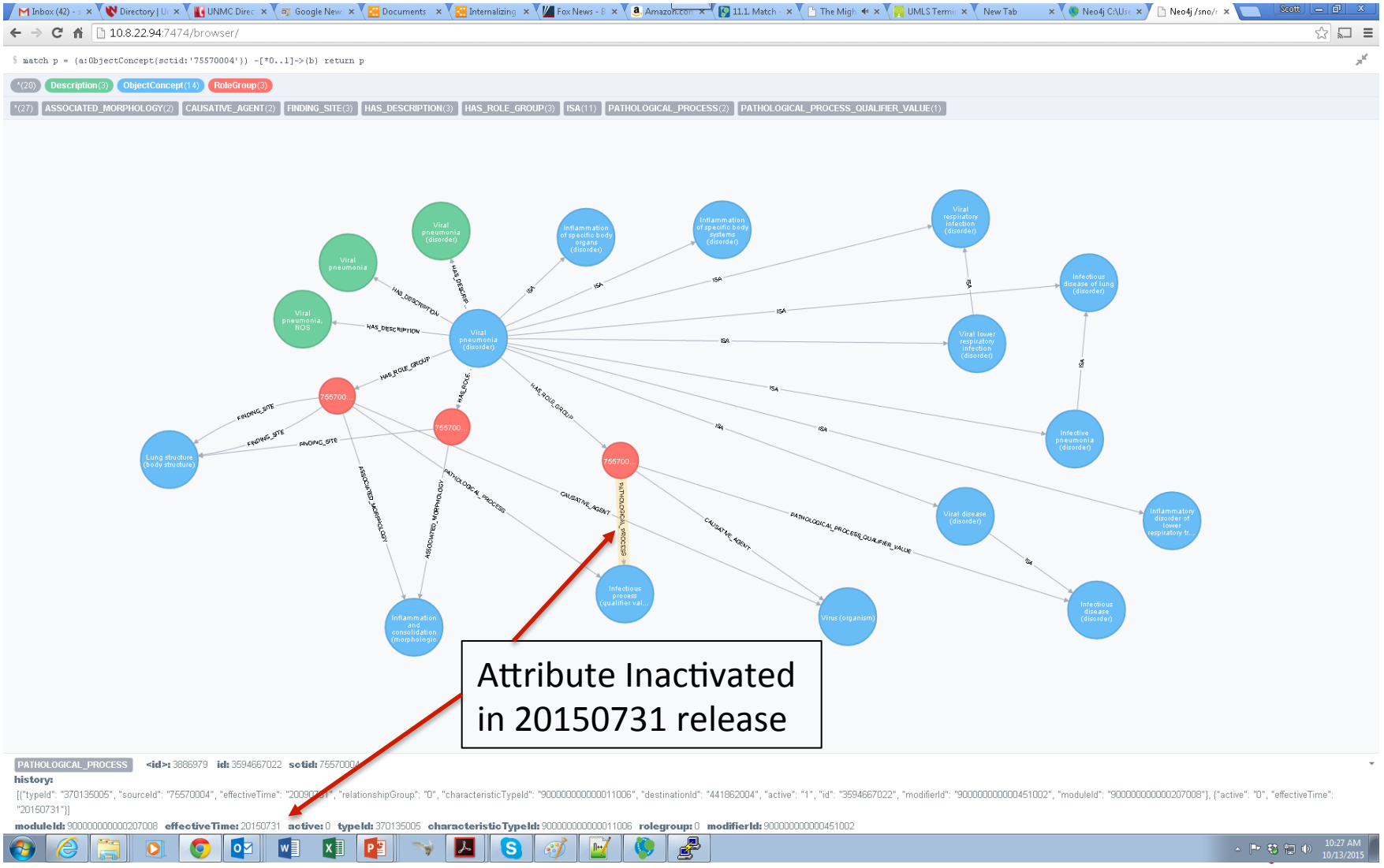
    - Beneficial for SNOMED CT sites to assess of effects of terminology updates on implementations

•Challenge accepted!

Challenge Met

- Following methods used previously for a single release
- Added property to maintain historical representations of SNOMED CT concepts and relationships
- Instantiated graph DB with classified, full RF2 release
  - 6 GB, ~425K concepts and ~6.9M relationships
- TC calculations created using the graph model by year match TC tables created for any single release year.
- Creation of delta TC table between any two years < 4 min
  - TC table year 1 < 30 sec
  - TC table year 2 < 30 sec
  - Delta TC table calculation and write to file – 2.5 min
- Creation of terminology update process with active patient data
  - Terminology updates “on the fly”

Example: Viral pneumonia



What about patient data?

- Added same patient data used in Snapshot graph DB
  - 465,000 patients
  - ~2.77 million associated problems/clinical findings (20140901 US extension)
  - GraphDB build on 20150901 US extension)

•Queried all SNOMED CT expressions with existing relationship to any patient AND Active status = ‘0’ (Inactive concept)

  - Return – 79 inactive concepts
  - Affected – 6134 distinct patients
  - All concept changes due to changes in 20150131 International release

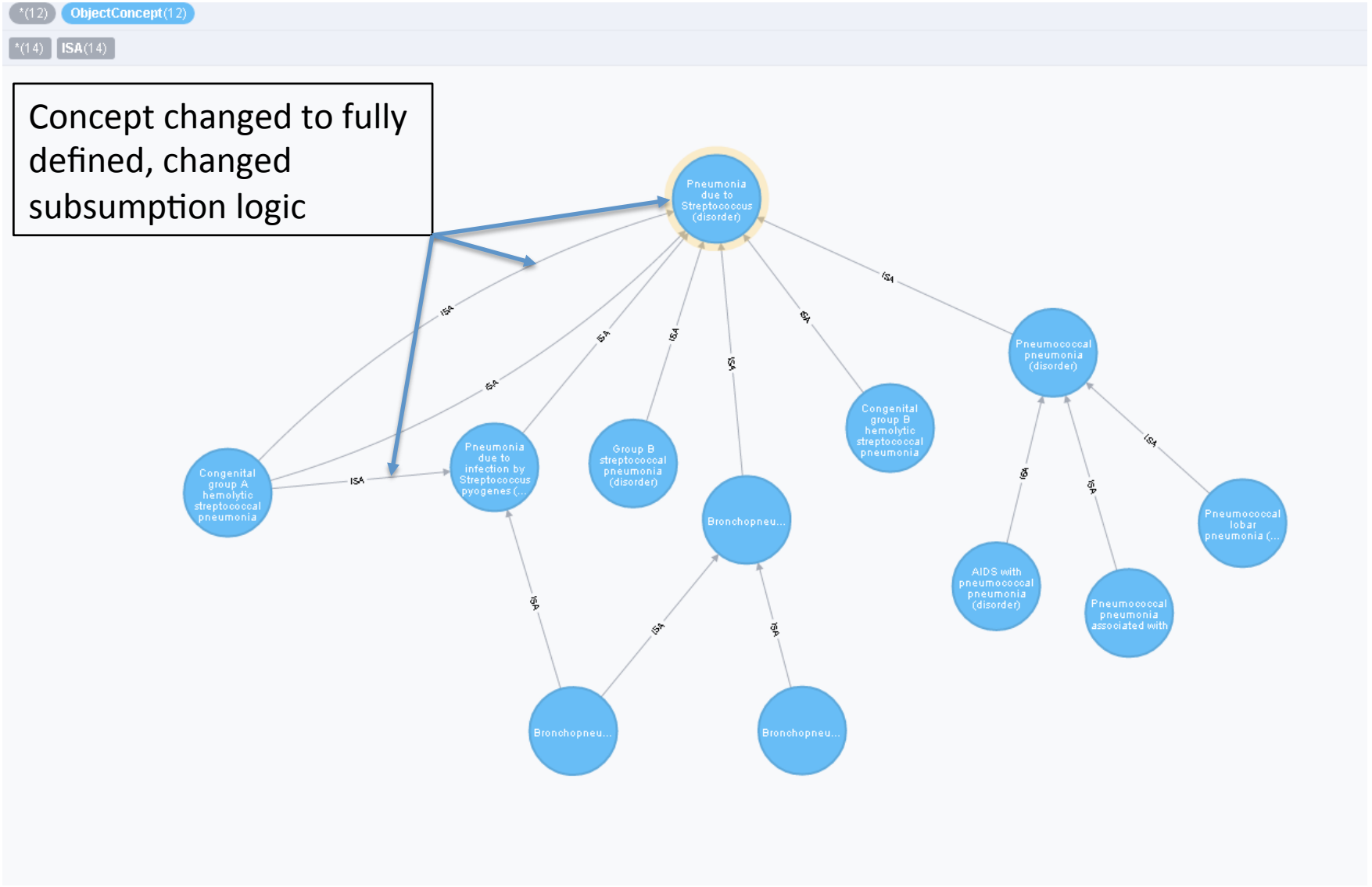
ID all patients with active diagnosis linked to inactive SNOMED CT concept

SCTID	Fully Specified Name	Patients
23346002	Sunburn (disorder)	7
91340006	Extrinsic asthma with status asthmaticus (disorder)	6
601000119109	History of bee sting allergy (situation)	1
71275003	Pseudoprimary aldosteronism (disorder)	17
431347008	Lipodystrophy associated with Human immunodeficiency virus infection (disorder)	4
312403005	Legionnaire's disease (disorder)	6
367530008	Spondyloepiphyseal dysplasia congenita (disorder)	3
440181000	Apparent life-threatening event (finding)	19
44008002	Somatotropin deficiency (disorder)	131
395657006	Pallister-Killian syndrome (disorder)	1
429081000124107	History of extracorporeal membrane oxygenation (situation)	15

What are the implications?

- Persistent and query-able representation of patient data over time in BOTH current and past SNOMED CT representations
- Quality metrics reporting based on any referenced point in time?
- Historical identification of patients with diagnoses that have been refined?
  - Perspective on medical knowledge/understanding
  - Epidemiologic study
- SNOMED CT quality reviews in real-time/impact on patient queries
  - Identification of changes and potential classifier issues in:
    - Concept deprecation
    - Subsumption changes
    - Defining relationships changes
    - Primitive vs. fully-defined

Example – Congenital B strep pneumonia



Where next?

- Dynamic environment to retain developing SNOMED CT content in anatomic pathology data (cancer synoptic data)
- Updated expressions accommodated as released and on demand
- Existing data with new SNOMED CT representation easily identified and modified.
  - No loss of historicity of data!
- Environment to test and prove out patient data in other domains
  - Microbiology?
  - Drug to bug to patient rapid identification?

References

1. Lee D, Cornet R, Lau F, de Keizer N. A survey of SNOMED CT implementations. J Biomed Inform. 2013 Feb;46(1):87-96.

2. Campbell WS, Campbell JR, West WW, McClay JC, Hinrichs SH. Semantic analysis of SNOMED CT for a post-coordinated database of histopathology findings. J Am Med Inform Assoc. 2014 Sep;21(5):885-92.

3. Campbell WS, Pedersen J, McClay JC, Rao P, Bastola D, Campbell JR. An alternative database approach for management of SNOMED CT and improved patient data queries. J Biomed Inform. 2015 Aug 21.

4. Campbell JR, Campbell WS, Hickman H, Pedersen J, McClay J. Employing complex polyhierarchical ontologies and promoting interoperability of i2b2 data systems. *[Accepted Proc AMIA Symp. 2015]*

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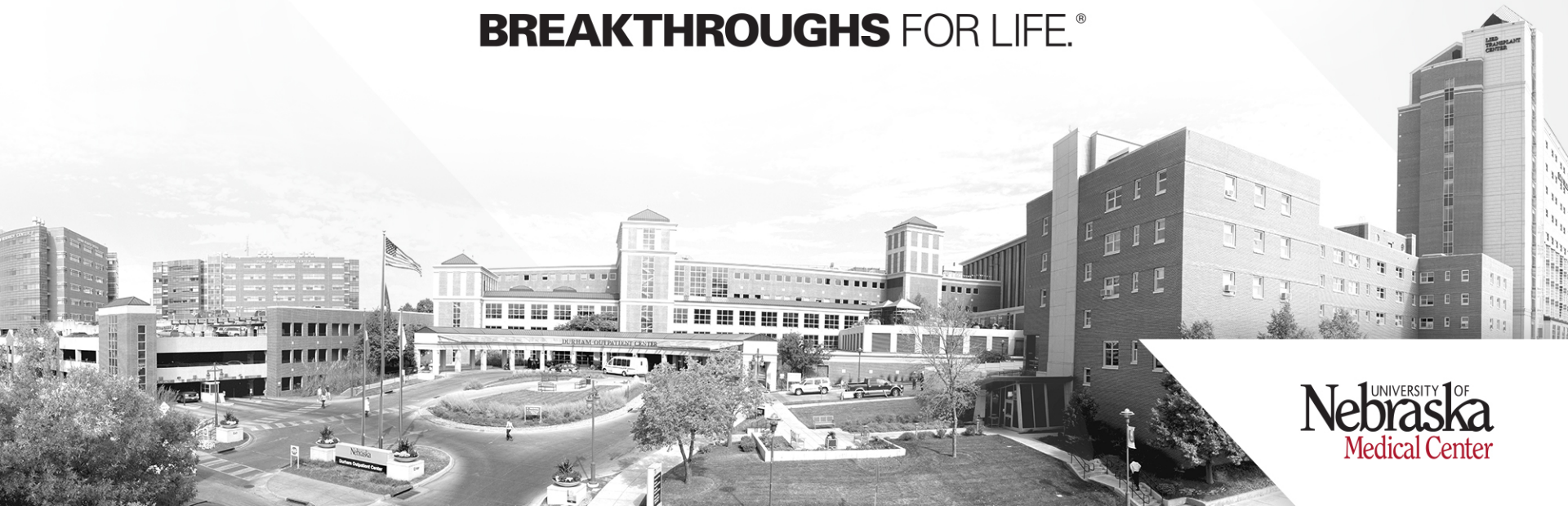

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