



LSDIS

Large Scale Distributed Information Systems



University of Georgia
Computer Science Department

Semantic empowerment of Health Care and Life Science Applications

[WWW 2006 W3C Track, May 26 2006](#)

[Amit Sheth](#)

[LSDIS Lab](#)

&

[Semagix](#)

University of Georgia

Joint work with Athens Heart Center, and CCRC, UGA



Part I: A Healthcare Application

Active Semantic Electronic Medical Record @ Athens Heart Center (use Firefox) (deployed since Dec 2005)

Collaboration between LSDIS & Athens Heart Center
(Dr. Agrawal, Dr. Wingate)

For on line demo: Google: Active Semantic Documents



Active Semantic Document

A document (typically in XML) with

- Lexical and Semantic annotations (tied to ontologies)
- Active/Actionable information (rules over semantic annotations)

Application: **Active Semantic EMR for Cardiology Practice**

- EMRs in XML
- 3 ontologies (OWL), populated
- RDQL -> SPARQL, Rules
- Services, Web 2.0



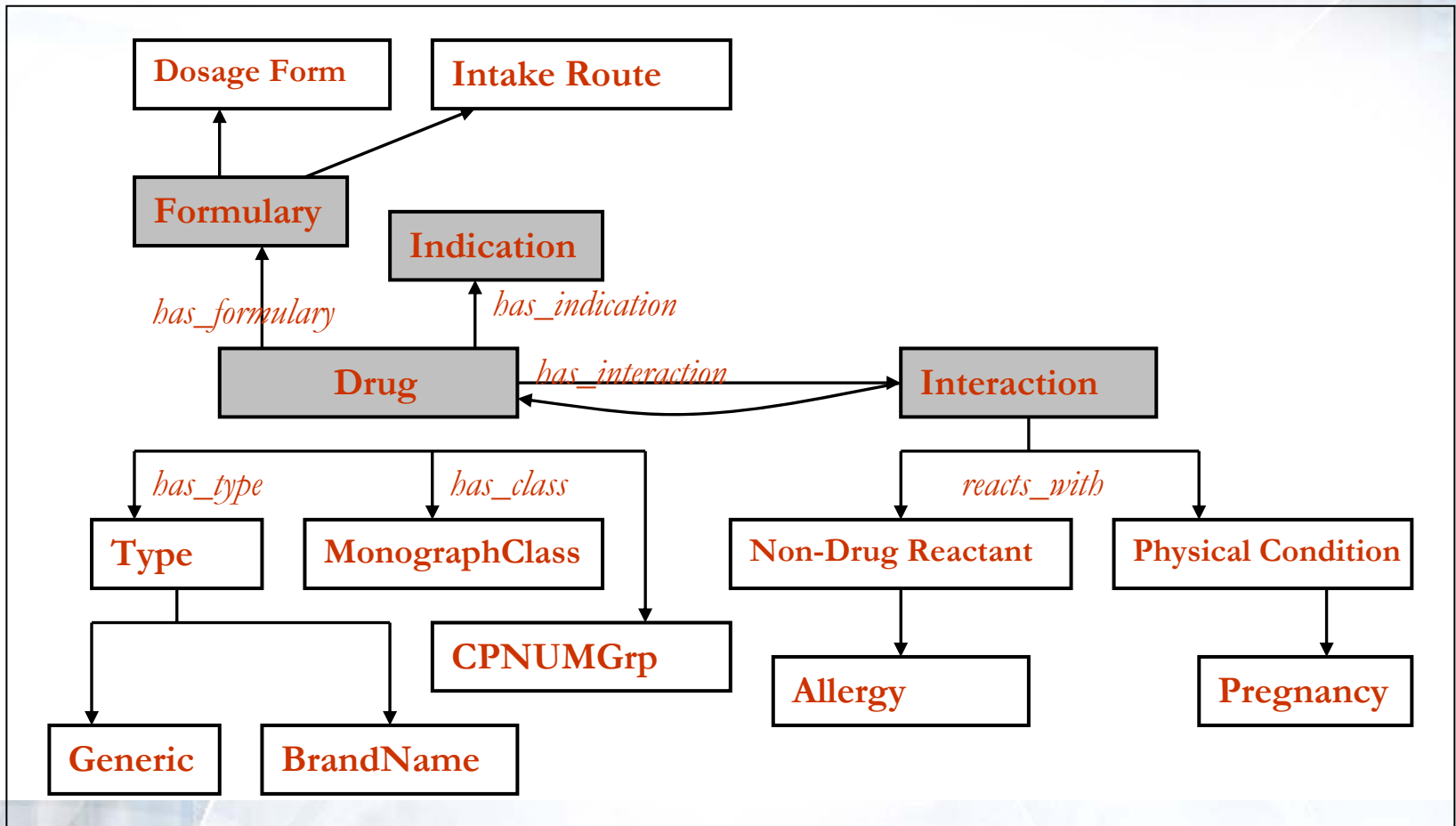
Active Semantic Electronic Medical Record

Demonstrates use of Semantic Web technologies to

- reduce medical errors and patient safety
 - accurate completion of patient charts (by checking drug interactions and allergy, coding of impression,...)
- improve physician efficiency, extreme user friendliness, decision support
 - single window for all work; template driven sentences, auto-complete, contextual info., exploration
- improve patient satisfaction in medical practice
 - Formulary check
- improve billing due to more accurate coding and adherence to medical guidelines
 - Prevent errors and incomplete information that insurance can use to withhold payment



One of 3 ontologies used (part of drug ontology)



Local, licensed and public (Snomed) sources to populated ontologies

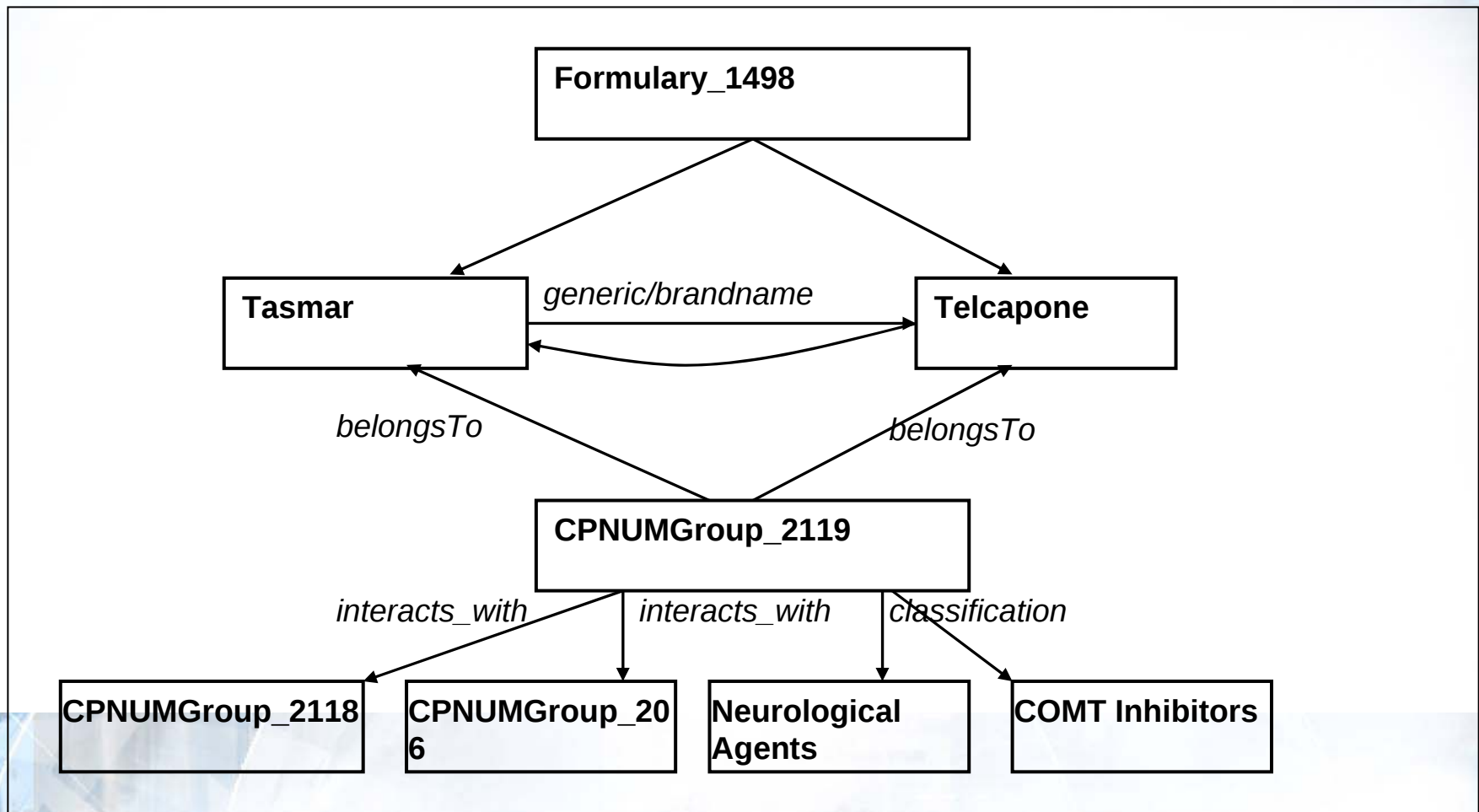


Example Rules

- drug-drug interaction check,
- drug formulary check (e.g., whether the drug is covered by the insurance company of the patient, and if not what the alternative drugs in the same class of drug are),
- drug dosage range check,
- drug-allergy interaction check,
- ICD-9 annotations choice for the physician to validate and choose the best possible code for the treatment type, and
- preferred drug recommendation based on drug and patient insurance information



Exploration of the neighborhood of the drug Tasmar





Active Semantic Doc with 3 Ontologies



Athens Heart Center
Jerek Chicken

325 PileORice Street, Athens, GA 30606

SSN: 123-45-6789

MR #: 555555

Sex: M

DOB: 01/02/1934

Visit on 10/28/2005

Age: 71

Other Physicians: Harry Wingate, M.D. **E** Kevin Adams, M.D. **E**

Family Practice
706-795-9588

Problem List:

1. Hypertension (365.04) **E**
2. Cholecystectomy (576.0) **E**
3. Chest Pain **E**

Chief Complaint: Evaluation of abnormal EKG status post abnormal Echo. Evaluation of aortic stenosis status post arterial examination. Cardiac clearance for aneurysm removal. Follow up of recent hospitalization at Barrow Community Hospital for acute myocardial infarction.

History of Present Illness: He was evaluated at Athens Regional Medical Center emergency room by Dr. Harry Wingate. He is here today for cardiac clearance for aneurysm removal. The patient reports chronic moderate burning and cramping chest pain located across the chest, which radiates to the arms. He reports that his chest pain is aggravated by movement. The patient reports difficulty breathing deeply. Patient's history is positive for the following cardiovascular risk factors: diabetes and family history of coronary artery disease.

Current Medications

Actos 30 mg, 1tab **E**

**Level 3
Drug Interaction**

Medications Affected

Coumadin tablets 10 mg, 1tab **I3 F E**
Viagra 50 mg, 1tab **I3 F E**
Zyrtec 5 mg, 1tab **E**
Zyvox 2 mg/ml, 1inj **A E**

Insurance Formulary

Allergies: LINEZOLID

Impressions:

1. Abdominal aortic aneurysm, advanced secondary to by a positive nuclear scan.
2. Abnormal cardiac study associated with chest tightness appears to be secondary to a noncardiac cause as evidenced by arterial scan of lower extremities.
3. Normal cardiac cath.

DrugAllergy



Explore neighborhood for drug *Tasmar*

Explore: Drug *Tasmar*

AHC Acct No: 222222 - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites

Address C:\lex\final.xml

Current Medications	
Intropin injection 40mg/ml, 1 inj qd I E	Intropin injection 40mg/ml, 1 inj qd I E
Tasmar tablets 200mg, 1 tab qd I E	Advil 100mg/5ml, 1 susp qd F E
	Tasmar tablets 200mg, 1 tab qd I E
	Tylenol extended release 650mg, 1 tab er qd A F E

Pharmacy: Carson's Commerce Drug Company
Phone: 706-754-4128
Phone: 706-335-3111

Allergies: AMPICILLIN, IVP DYE, PENICILLIN, TYLENOL

Past Medical History: No past trauma.

Family History: Mr. Prabhakar has a positive family history of coronary artery disease. The patient's **crap2** is deceased.

Psychosocial: Mr. Prabhakar resides in a apartment home. He is lives with her daughter to hkk. He has excellent social support.

Life History:

Review of Systems:

General Patient reports daily chills associated with chest pain. These symptoms have not been worked up by his primary care physician. Patient reports recent unintentional weight gain. This problem has not been worked up by his primary care physician.!!error!! Patient reports recent onset of severe trouble falling asleep. This problem has been working up by his primary care physician.

HEENT The patient reports migraine headache.

Genitourinary Patient denies dysuria. Patient complains of recent onset of hematuria. Patient complains of chronic presence of hesitancy. Patient denies dribbling. Patient complains of recent onset of burning with urination.

Hematologic Patient reports history of blood transfusion as a result of anemia. Patient reports he did experience a transfusion reaction.

Skin Patient reports frequent of mild pruritis associated with weakness. This problem has been worked up by the patient's dermatologist. Patient reports a walnut-sized keratosis that is located over the entire body.

Psychiatric Patient admits to a history of panic attacks that is currently managed by common mental health. His symptoms are felt to be not under control.

Vital Signs: Height: 170 Weight: 280 lbs BP: 120/80 Pulse: 80 Respirations: 20

Physical Examination:

General The patient appears the stated age.

Done My Computer



Explore neighborhood for drug *Tasmar*

Query View - DrugOnt_test_alt

Semantic browsing and querying-- perform decision support (how many patients are using this class of drug, ...)

Nodes of Interest

☐ Use Selected (none selected)

☒ Search By Name

Name:

☐ case sensitive

☐ regular expression

☒ Restrict Node Types

Defined Class

Enumeration

Individual

Logical Operation

Primitive Class

RDFS Class

Restriction

Arcs of Interest

☒ Restrict Arc Types

equivalent to

has instance

has subclass

has_brandname_equivalent

has_brandname_equivalent (Domain>Range)

has_brandname_equivalent (Necessary and Sufficient)

has_brandname_equivalent (Necessary)

has_brandname_prescription_drug

has_brandname_prescription_drug (Domain>Range)

has_brandname_prescription_drug (Necessary and Sufficient)

has_brandname_prescription_drug (Necessary)

has_cpnum_group

Neighbours

☒ Show Neighbours

Arc Direction

☒ Outgoing and Incoming Arcs

☐ Outgoing Arcs

☐ Incoming Arcs

☒ Restrict Levels

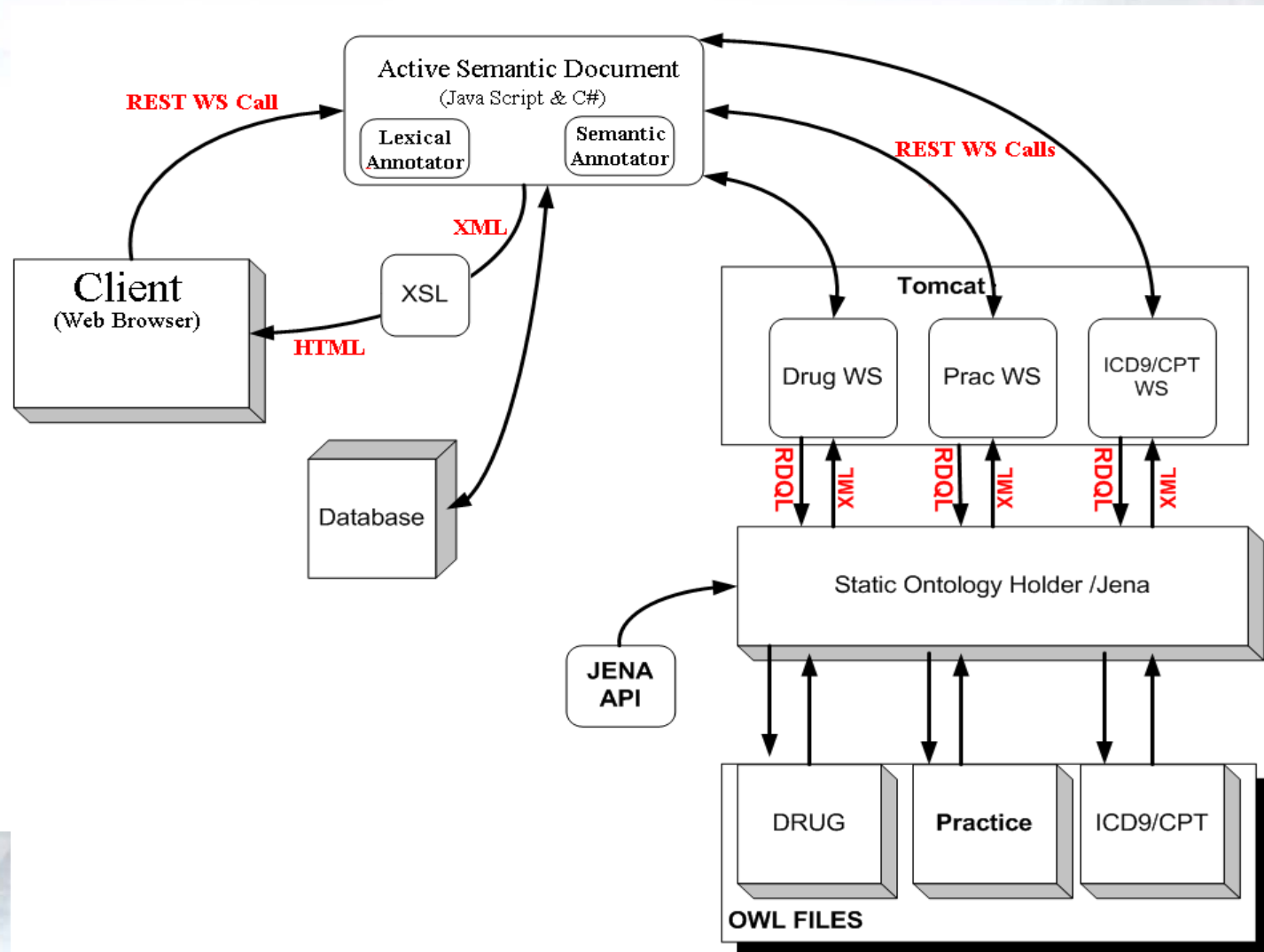
Levels:

Results

Query



Software Architecture



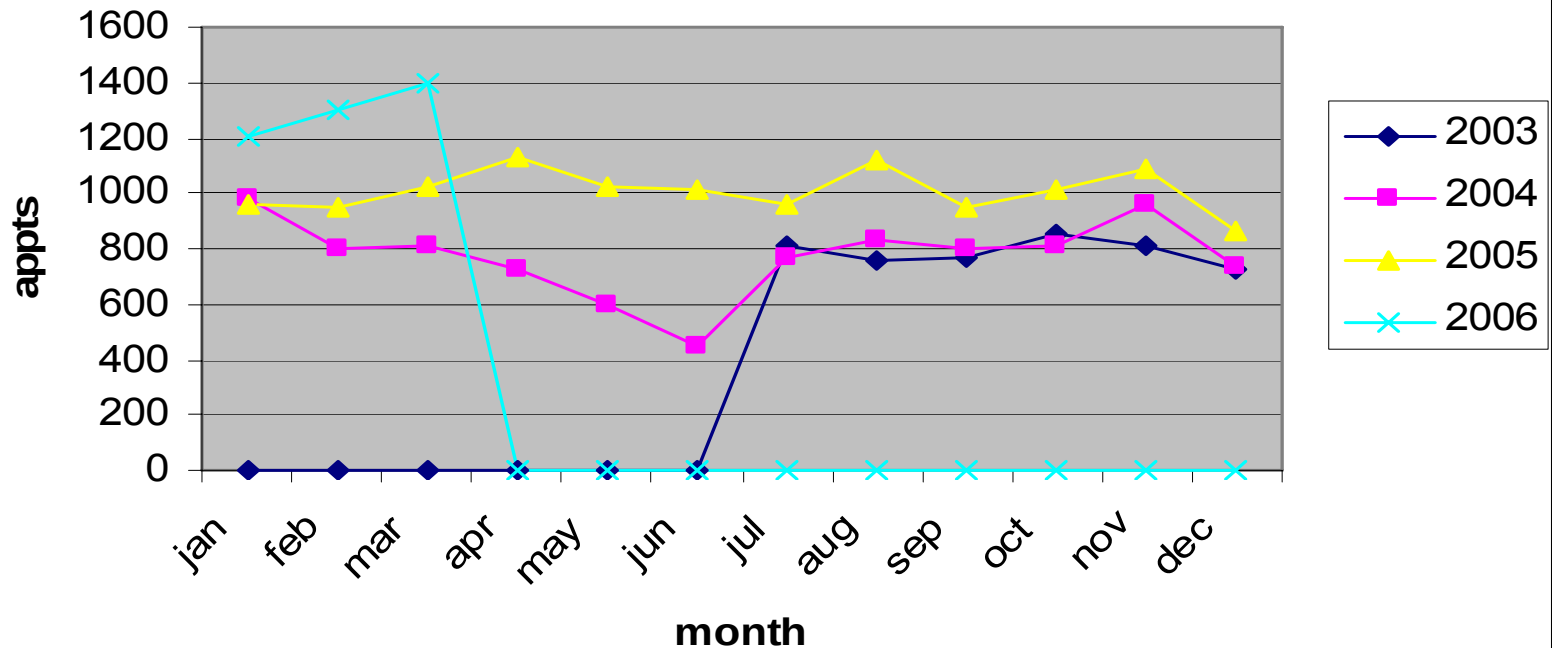


ROI



Athens Heart Center Practice Growth

Appointments (excluding cancelled/rescheduled but including noshow cases)



Increased efficiency demonstrated as more encounters supported without increasing clinical staff



Chart Completion before the preliminary deployment of the ASMER

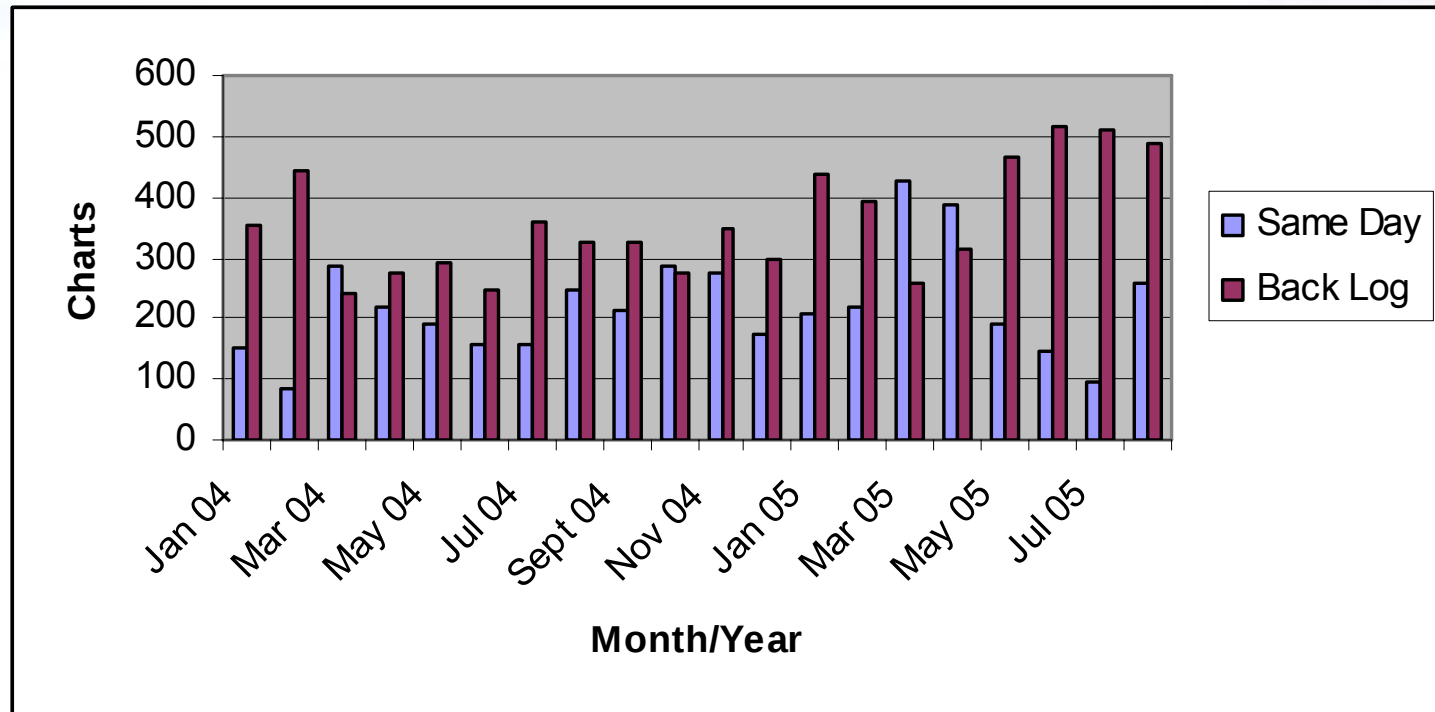
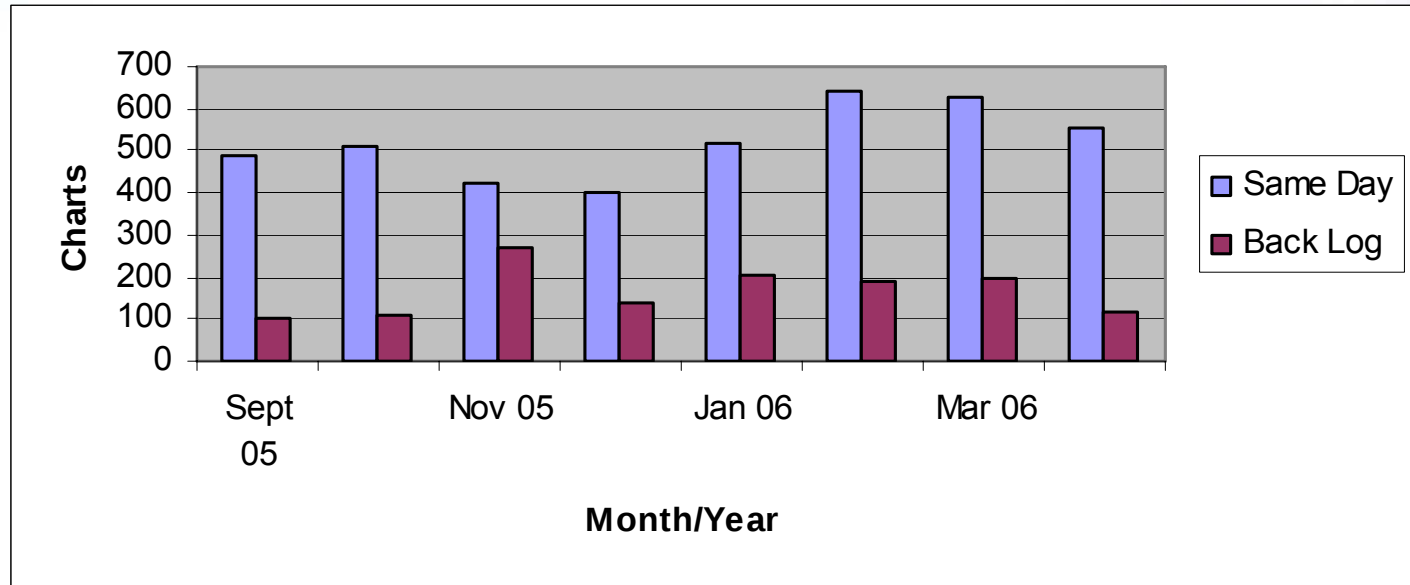


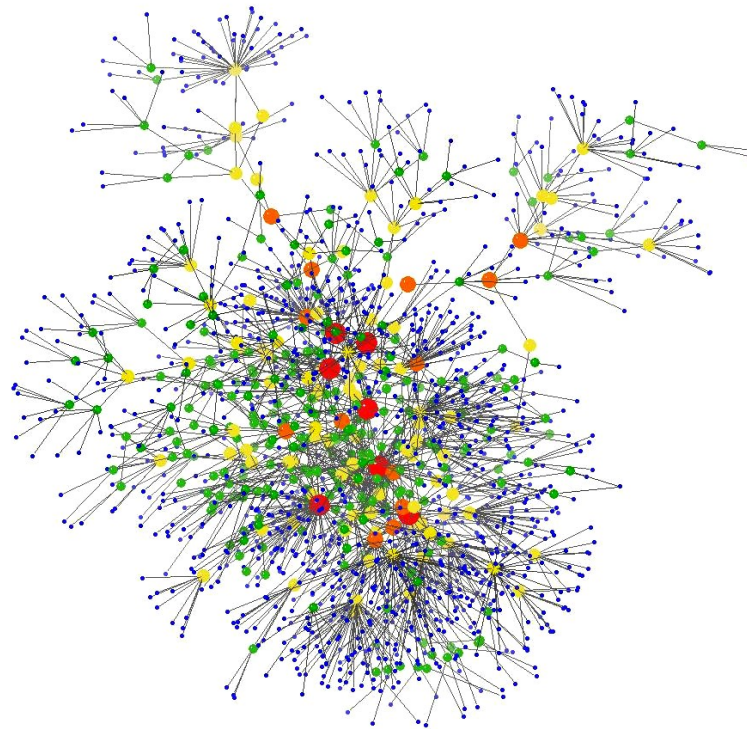


Chart Completion after the preliminary deployment of the ASMER





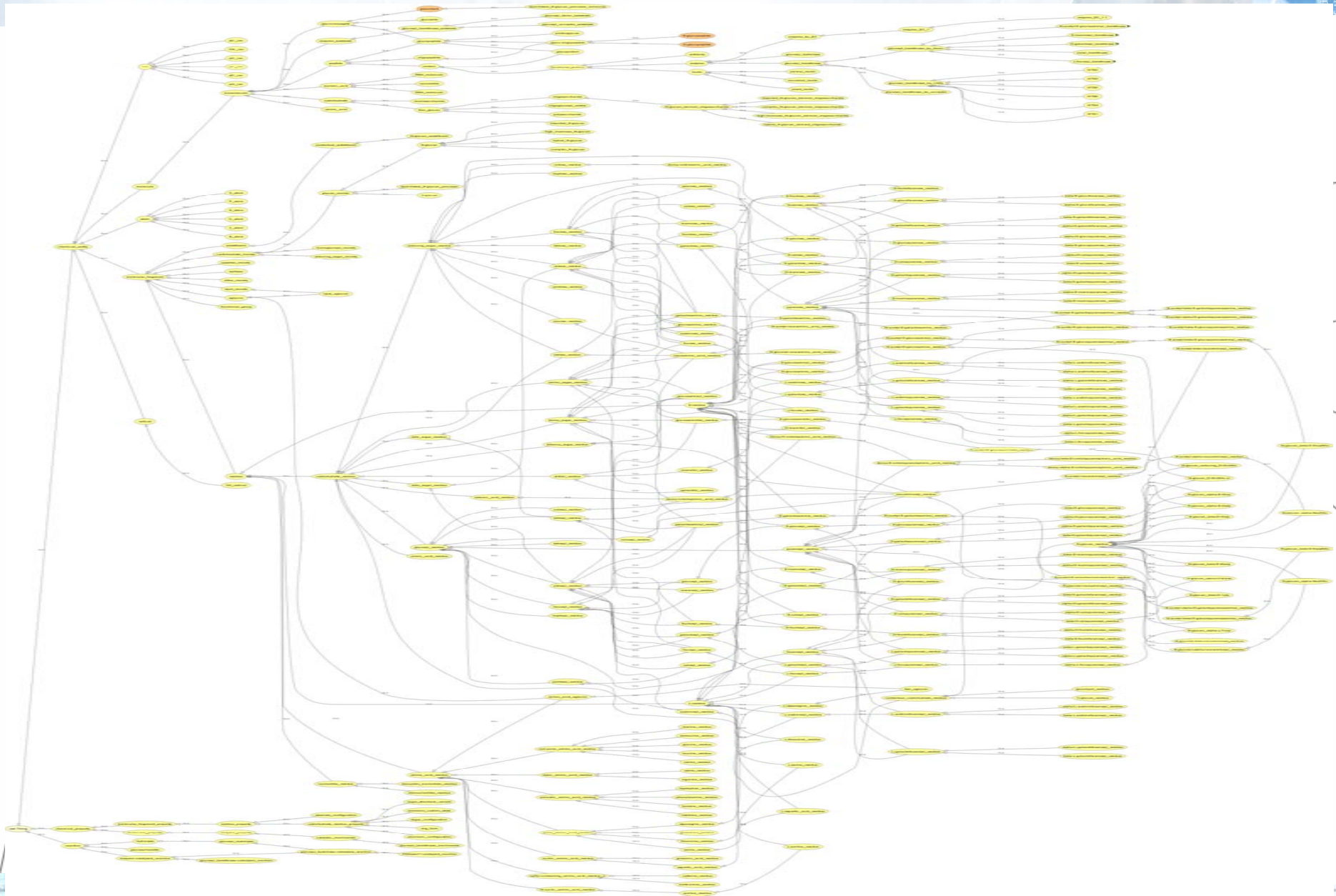
Applying Semantic Technologies to the Glycoproteomics Domain





Quick take on bioinformatics ontologies and their use

- GlycO and ProPreO - among the **largest populated ontologies** in life sciences
- Interesting aspects of structuring and populating these ontologies, and their use
- GlycO
 - a comprehensive domain ontology; it uses simple **'canonical' entities** to build complex structures thereby avoids redundancy → ensures **maintainability** and **scalability**
 - Web process for entity disambiguation and common representational format → populated ontology from **disparate data sources**
 - Ability to display biological pathways
- ProPreO is a comprehensive ontology for **data** and **process provenance** in glycoproteomics
- Use in annotating experimental data, high throughput workflow





GLYCO ONTOLOGY

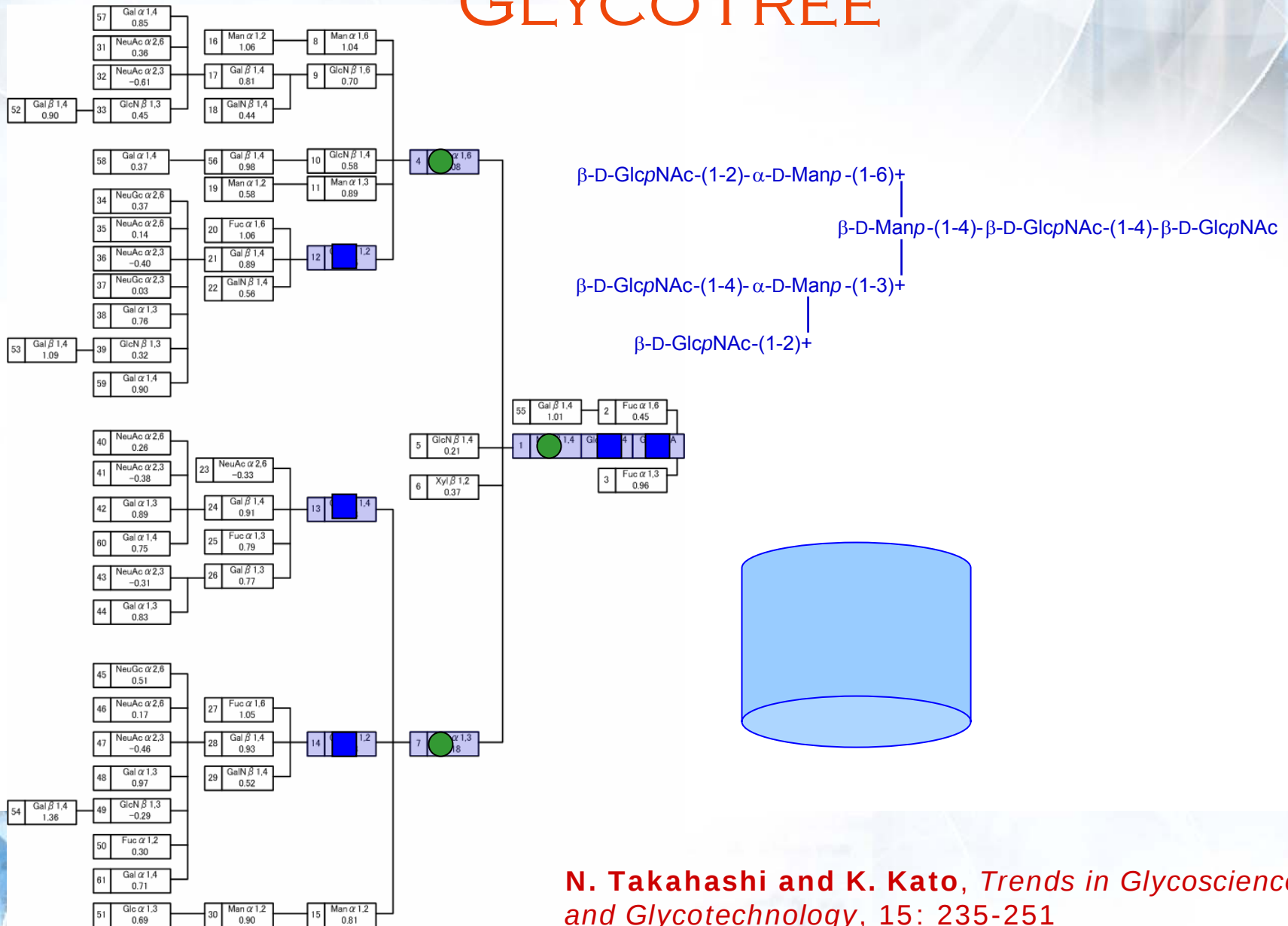
- **Challenge** – model hundreds of thousands of complex carbohydrate entities
- But, the differences between the entities are small (E.g. just one component)



- How to model all the concepts but preclude redundancy → ensure **maintainability**, **scalability**



GLYCOTREE



N. Takahashi and K. Kato, *Trends in Glycosciences and Glycotechnology*, 15: 235-251

Ontology population workflow




GLYCAN: G00020

Help

Entry	G00020 Glycan
Composition	(GlcNAc) 5 (Man) 3 (Asn) 1
Mass	1502.4 (Asn)
Structure	GlcNAc G00020 KCF file KCaM
Class	Glycoprotein; N-Glycan
Reaction	R05987 R05991
Pathway	PATH: map00510 N-Glycan biosynthesis
Enzyme	2.4.1.145 2.4.1.155
Ortholog	KO: K00738 alpha-1,3-mannosylglycoprotein beta-1,4-N-acetylglucosaminyltransferase KO: K00744 alpha-1,3(6)-mannosylglycoprotein beta-1,6-N-acetylglucosaminyltransferase
Other DBs	CCSD: 4362 5058 7636 30028 33048 34937 35723 42024 43245
LinkDB	All DBs
KCF data	Show

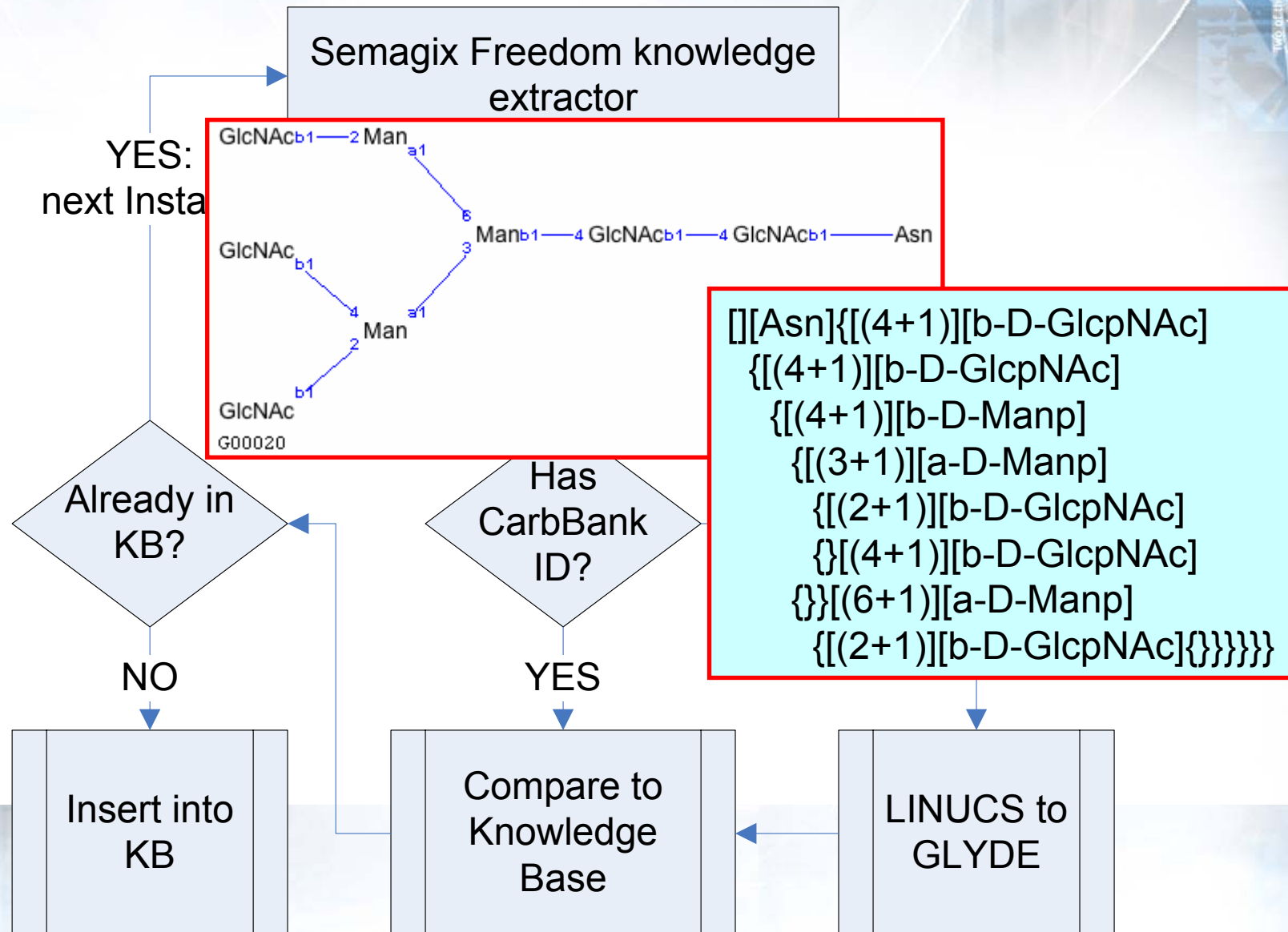
C to
JCS

CS to
CYDE

Base



GLYCO POPULATION

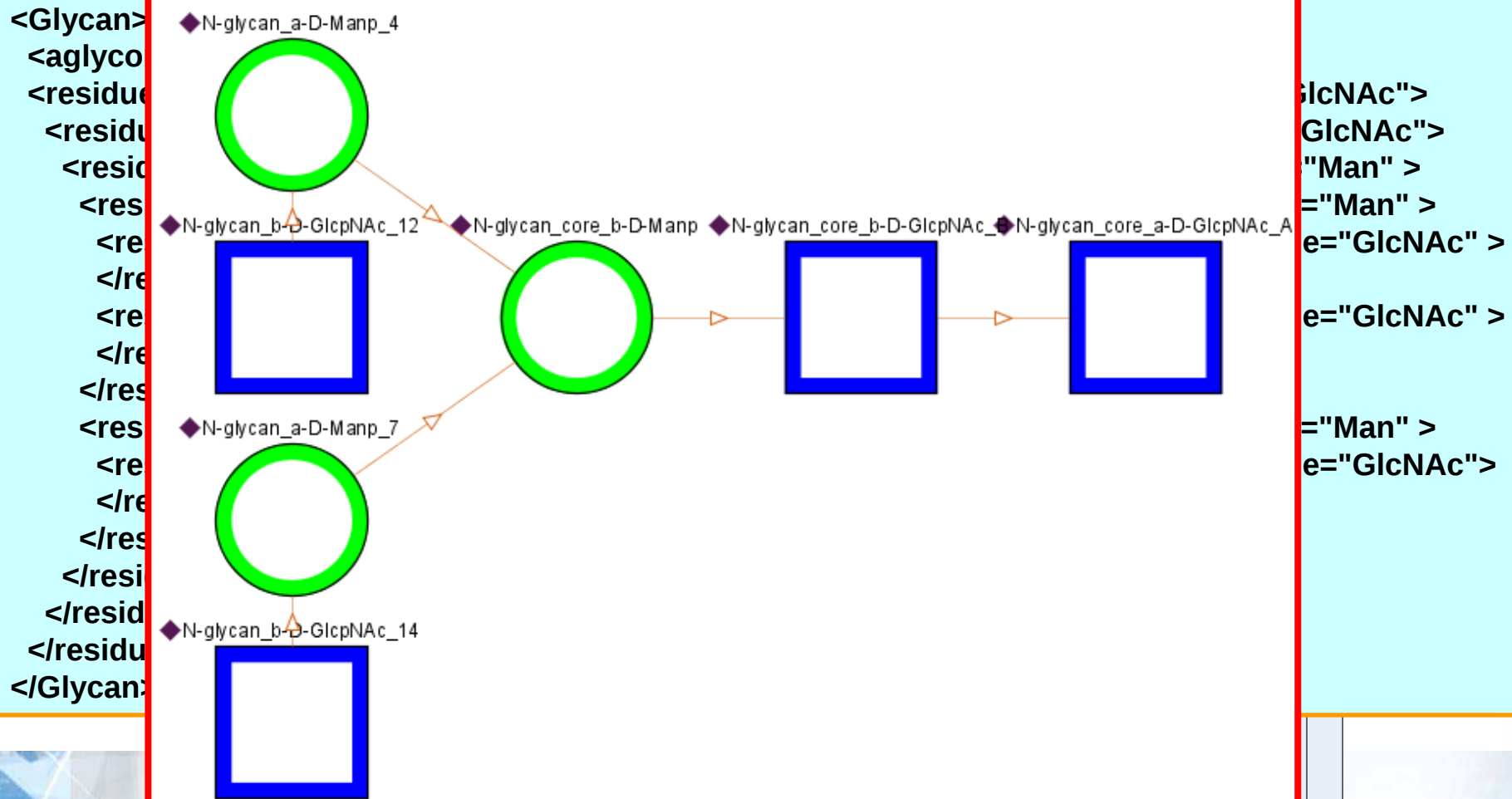




Ontology Population Workflow



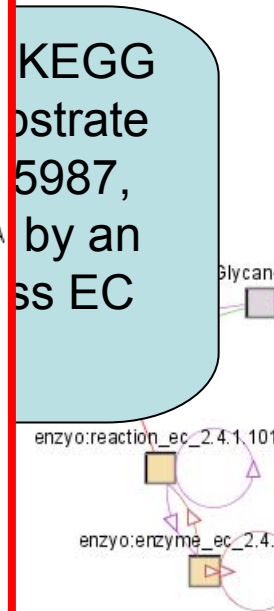
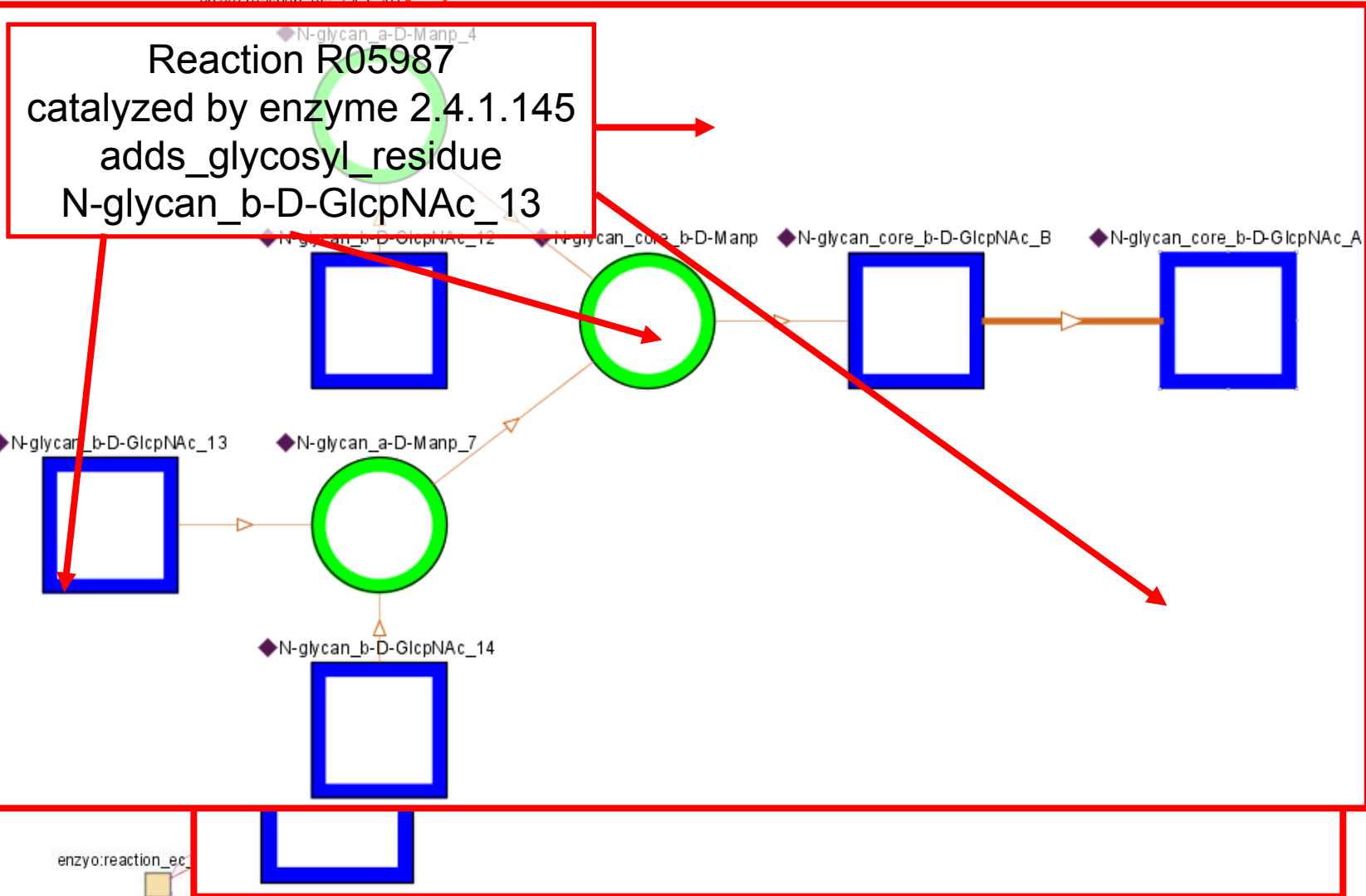
Semagix Freedom knowledge
extractor



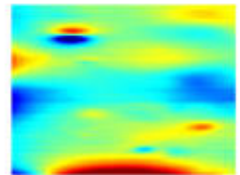
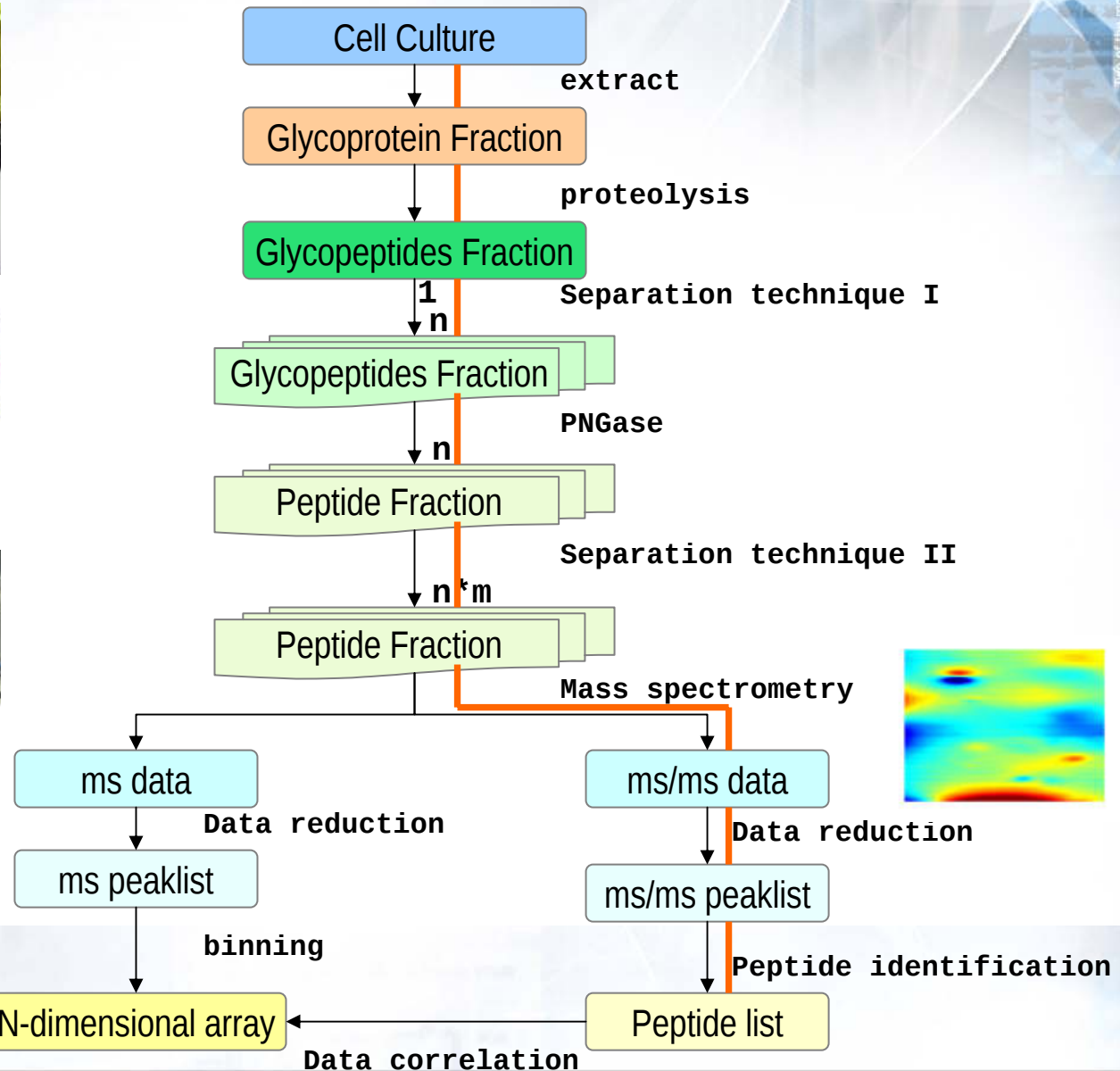
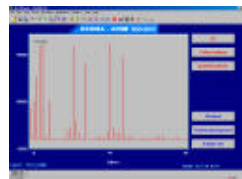
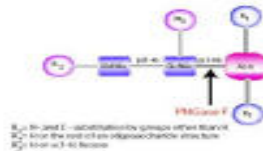
01 06 07



Zooming in a little ...



N-Glycosylation Process (NGP)



Glycopeptide identification
and quantification

Signal integration



Semantic Annotation of MS Data



Two of the most active
Very Twincubus upon
TEOR / Semantic Web

830.9570	194.9604	2
580.2985	0.3592	
688.3214	0.2526	
779.4759	38.4939	
784.3607	21.7736	
1543.7476	1.3822	
1544.7595	2.9977	
1562.8113	37.4790	
1660.7776	476.5043	

parent ion m/z

parent ion charge

parent ion abundance

fragment ion m/z

fragment ion abundance

ms/ms peaklist data

Two of the most active
very (which builds upon
TEOP-S. See also Web

```
<ms/ms_peak_list>
<parameter
instrument="micromass_QTOF_2_quadropole_time_of_flight_mass_s
pectrometer"
mode = "ms/ms"/>
<parent_ion_mass>830.9570</parent_ion_mass>
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<z>2</z>
<mass_spec_peak m/z = 580.2985 abundance = 0.3592/>
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<mass_spec_peak m/z = 784.3607 abundance = 21.7736/>
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<mass_spec_peak m/z = 1562.8113 abundance = 37.4790/>
<mass_spec_peak m/z = 1660.7776 abundance = 476.5043/>
</ms/ms_peak_list>
```

Annotated ms/ms peaklist data



Summary, Observations, Conclusions

- Deployed health care application that uses SW technologies and W3C recommendations with some understanding of ROI
- New methods for integration and analysis/discovery in biology driven by large populated ontologies
- Projects, library and resources including ontologies at the LSDIS lab:

<http://lsdis.cs.uga.edu>, [WWW2006 paper](#)