Seedpod - A Model Driven Laboratory Information Management System*

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* PhD thesis project, Department of Biomedical informatics, University of Washington. Thesis adviser is Dr. Jim Brinkley.
Problem Statement

• Biomedical researchers need data management tools that are more robust than excel spreadsheets. However, the rate that biomedical informaticists have been developing laboratory information management systems (LIMS) can’t keep up with the demand for LIMS and the rate that experiment protocols change.
Background: Biomedical Research

- UW research, single unit recording during neurosurgery

Experiment trials

1. [Image of a cat]
2. [Image of shoes]
3. "Table" (Audio)
4. [Image of a boat]

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0124_ID1_1_1_UF.txt - Notepad
Background: Biomedical Data Management

- Needs from the biomedical researchers*
  - Data handling problem has become a barrier to progress of research
  - Available computational solutions are prohibitively expensive
  - Available solutions are too complex for their needs
  - No solution to their specific problems

Background: Biomedical Informatics

- LIMS development is challenging
  - Diversity in biomedical research makes LIMS solutions lab-specific.
  - Research protocol change frequently, every 4 months to a year.
Biomedical Researchers’ Wish List

• **Data management** (Seedpod)

• Data archiving

• Data analysis

• Protocol management

• Workflow management

• Data sharing
Aims

- **Data management** for researchers
  - Organize and store large heterogeneous data set
  - Enter and browse data through a user friendly interface
- **LIMS development** for informaticists
  - Cost-efficient development
  - Generalizable solution
Seedpod Takes Model Driven Approach

Database \[\leftrightarrow\] Server \[\leftrightarrow\] Web-base User Interface
Seedpod Takes Model Driven Approach
Seedpod Takes Model Driven Approach

Model

Data Model

GUI customization

Database

Server

Web-base User Interface
Seedpod Takes Model Driven Approach

Model

Data Model

GUI customization

Core Application

Database

Server

Web-base User Interface
The Components

Protégé Model

Data Model

GUI customization

LIMS

RDB

Server Application

Web-base User Interface
The Components

1. Protégé Model
   - Data Model
   - GUI customization

LIMS

- RDB
- Server Application
- Web-base User Interface

Manual
The Components

1. Protégé Model
   - Data Model
   - GUI customization

2. Transformation

LIMS
- Meta-data
- RDB
- Experiment data

- Server Application
- Web-base User Interface
The Components

1. Protégé Model
   - Data Model
   - GUI customization

2. Transformation

3. LIMS
   - Meta-data
   - RDB
   - Experiment data
   - Server Application
   - Web-based User Interface
Part 1: Create a Protege model of LIMS
Part 1: Create a Protege model of LIMS
Part 1: Create a Protege model of LIMS
Part 2: Automatically Transform Protege Model to Relational Schema

CREATE TABLE `Family_Study` (  
    ID INTEGER PRIMARY KEY,  
    city VARCHAR (50),  
    zip VARCHAR (5),  
    address VARCHAR(100),  
    family_study_ID INTEGER);  

CREATE TABLE `Subject` (  
    ID INTEGER PRIMARY KEY,  
    dob DATE,  
    subjectID INTEGER,  
    last_name VARCHAR(50), ...
CREATE TABLE Neuron ( 

... 

);
CREATE TABLE Neuron (  
  
);
Transform Class ➔ Table

CREATE TABLE Neuron (

  ...

);
Transform Class ➔ Table

CREATE TABLE Neuron (
   ...
);

Logo courtesy of http://protege.stanford.edu/
CREATE TABLE Neuron (  
  ID INTEGER PRIMARY KEY,  
city VARCHAR (50),  
zip VARCHAR (5),  
address VARCHAR(50),  
family_study_ID INTEGER);
CREATE TABLE Neuron ( 
    ID INTEGER PRIMARY KEY,
    city VARCHAR (50),
    zip VARCHAR (5),
    address VARCHAR(50),
    family_study_ID INTEGER);

Attribute, Foreign Key
CREATE TABLE Neuron (  
    ID INTEGER PRIMARY KEY,  
    city VARCHAR (50),  
    zip VARCHAR (5),  
    address VARCHAR(50),  
    family_study_ID INTEGER)
CREATE TABLE Neuron (  
    ID INTEGER PRIMARY KEY,  
    city VARCHAR (50),  
    zip VARCHAR (5),  
    address VARCHAR(50),  
    family_study_ID INTEGER);
Extended Slot Definition To Bridge Model Differences Between Protege and Relational Model
Extended Slot Definition To Bridge Model Differences Between Protege and Relational Model

![Protege Interface for Extended Slot Definition](protege_interface.png)
Transforming 1-to-many Relationship

**Family_Study Class**

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Logo courtesy of http://protege.stanford.edu/
Transforming 1-to-many Relationship

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Logo courtesy of http://protege.stanford.edu/
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Logo courtesy of http://protege.stanford.edu/
Transforming 1-to-many Relationship

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</table>

Logo courtesy of http://protege.stanford.edu/
Transforming Hierarchy

Autoimmune_Disease_Subject
ID
dob*
ref_physician

NOP_Subject
ID
dob*
CREATE VIEW Subject AS
Select ID, dob
from Autoimmune_Disease_Subject
UNION
Select ID, Modality
from NOP_Subject;
Database

- Meta-data
  - Model
  - UI
  - Model-Mapping
- Experiment data
  - Schema specific to lab application
# Meta-data Tables

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</table>
Part 3: Set-up Web Server Application

- Config database connectivity
- Load meta-data
- Interpret model (no hard-coded data objects)
- Dynamically generate web pages for browsing experiment data and data entry
Part 3: Set-up Web Server Application

- Config database connectivity
- Load meta-data
- Interpret model (no hard-coded data objects)
- Dynamically generate web pages for browsing experiment data and data entry
Browse Data on the Web
Data Entry

![Image of a data entry form for an Autoimmune_Disease_Subject in Seedpod LIMS](image-url)

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<th>Value</th>
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</tr>
<tr>
<td>birth order</td>
<td></td>
</tr>
<tr>
<td>First Name</td>
<td></td>
</tr>
<tr>
<td>Biopsy?</td>
<td>yes</td>
</tr>
</tbody>
</table>

**Class Information**
- name: Autoimmune_Disease_Subject
- MetaCls: RDB_CLASS
- Concrete: true
- InLine: false

**Tools**
- Create new Instance
- New Autoimmune_Disease_Subject
- Browse Instances
- Create similar
- Browse relations

**Date and Time**
Wed Mar 19 05:29:25 EDT 2008
Customize GUI Components
Customize GUI Components
Model Independent Application

Single Unit Recording Model
Model Independent Application

Single Unit Recording Model

Transformation

SUR Database
Model Independent Application

- Single Unit Recording Model
- SUR Database
- Transformation
- Seedpod Server
- SUR LIMS Web UI
Model Independent Application

- Single Unit Recording Model
- SUR Database
- Transformation
- Seedpod Server
- SUR LIMS Web UI
- Lupus Study Model
Model Independent Application

- Single Unit Recording Model
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- Seedpod Server
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Model Independent Application

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- SUR Database
- Transformation
- Seedpod Server
- Lupus Study Model
- Lupus Database
- SUR LIMS Web UI
- Lupus LIMS Web UI
Model Independent Application

- Manual
- Single Unit Recording Model
- Lupus Study Model
- Transformation
- Seedpod Server
- SUR Database
- Lupus Database
- SUR LIMS Web UI
- Lupus LIMS Web UI
Model Independent Application

Manual

Single Unit Recording Model

Lupus Study Model

Automatic

Transformation

Seedpod Server

SUR Database

Lupus Database

SUR LIMS Web UI

Lupus LIMS Web UI
## System Evaluation

<table>
<thead>
<tr>
<th>Seedpod Aim</th>
<th>Significance</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>More robust way to manage data</td>
<td>Allowing scientists to store and manage data in a relational database improves efficiency and query capabilities.</td>
<td>Compare a user query in Excel vs Relational database. Compare the amount of time and effort required. For example, ask for an aggregate question, ask someone to do that in excel. And then have a DBA to write the same query and get the result.</td>
</tr>
<tr>
<td>Reduce expertise required to LIMS development</td>
<td>Less expertise required by using Seedpod lowers the complexity and increases efficiency of system development</td>
<td>In the past, LIMS needs to be developed with a domain subject expert, someone who understands model design, relational database implementation, system engineering, and software development. Seedpod only requires a DSE and someone that understands how to model the data in Protégé.</td>
</tr>
<tr>
<td>Bridge the gap between domain subject matters and engineers</td>
<td>Reducing the upfront knowledge learning on the account of the researchers</td>
<td>Researchers and data model engineers can converse purely in terms of the domain subject and stay away from technical jargons of database development. The model makes it easier to say something about the data.</td>
</tr>
<tr>
<td>Lower cost</td>
<td>Increased reusability</td>
<td>The system only needs to be set up once and can be used to serve a community of labs.</td>
</tr>
<tr>
<td>Reduce the amount of time to make changes</td>
<td>Development can now keep up with change of experiment protocol</td>
<td>In the past, when experiment protocol changes, it may take another round of development time to create an experiment management system. Seedpod uses the amount of time to understand data model and the time to model.</td>
</tr>
</tbody>
</table>
## Transformation Evaluation

<table>
<thead>
<tr>
<th>Seedpod Aim</th>
<th>Significance</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completeness</td>
<td>Is all information from protege model captured</td>
<td>List all entities in Protege and see if they have 100% coverage in the RDB Schema</td>
</tr>
<tr>
<td>Minimality</td>
<td>No redundant information</td>
<td>Test for a normalized database. Data is not captured redundantly.</td>
</tr>
<tr>
<td>Understandability</td>
<td>Subjective evaluation of whether the schema is easily understandable. (This is usually a trade off with completeness and minimality)</td>
<td>Have another DBA look at the schema and see if that’s understandable.</td>
</tr>
</tbody>
</table>
Conclusion

• Seedpod
  • Provides a data management solution for biomedical researchers
  • Cost-effectiveness development for biomedical informaticists

• Future work:
  • A better modeling environment
  • Change management, protocol management
  • Data analysis, query interface, security and privacy
Thank you!

• Questions?

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