# Technologies of Semantic WEB as an environment of application development and integration

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AICTS'2021, December, 06, 2021
Irkutsk, Russia

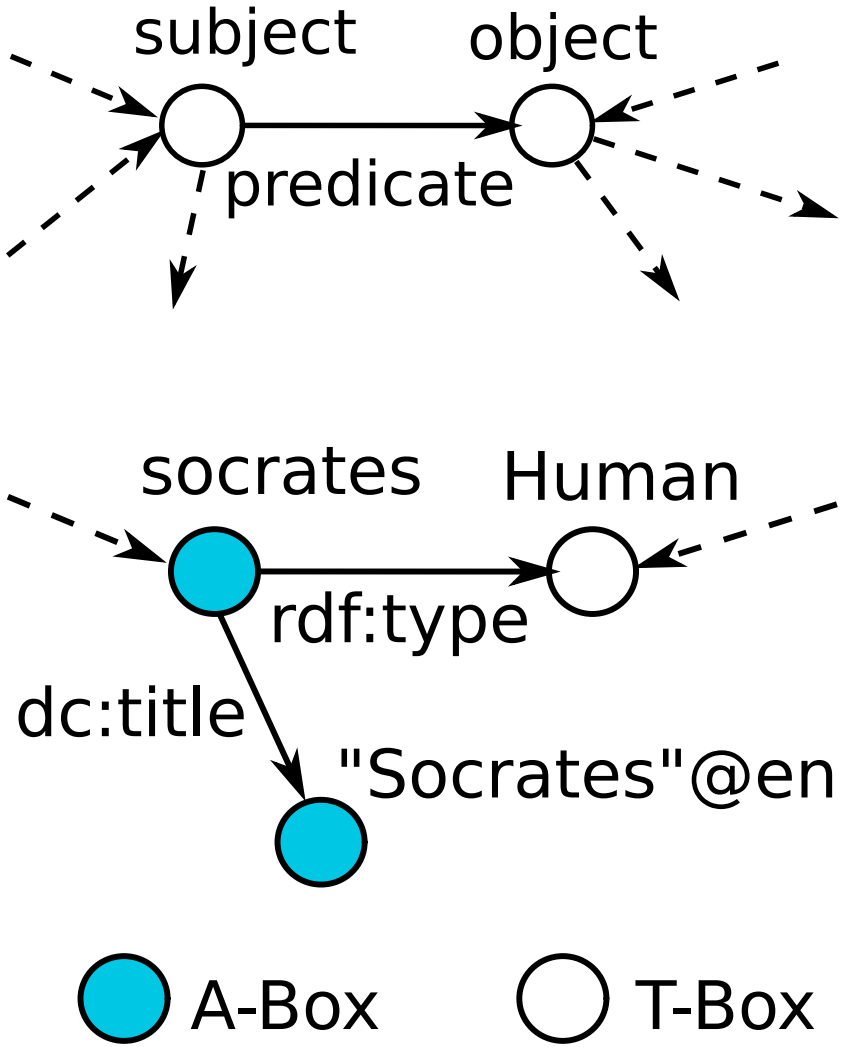
# Research and Development objectives

**Main objective** of the activity is to construct data integration tools based on the **standardized** Semantic WEB technologies.
The following aspects are under consideration:

1. Ontological model representation
2. Application data representation
3. Model transformation
4. Document publication
5. Application integration via knowledge graph data documents

# Representation of ontological models

The ontologies are represented with `<subject, predicate, object>` **triples** as **graphs**, and there is frequently a **context**, the graph itself.




The subjects, the predicates and *some* objects are **URI/IRI**. *E.g.*, `http://purl.org/dc/terms/` defines the **namespace** "`dc`".

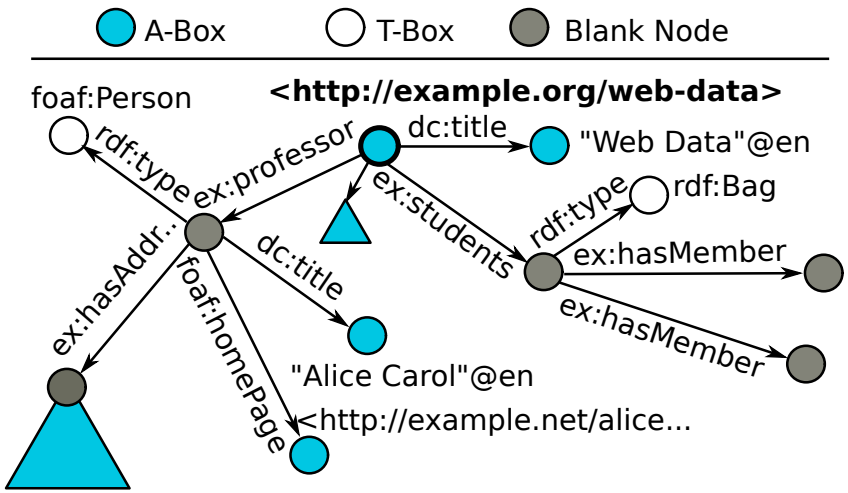
*Other* subjects are **literals**.

All **XML** properties are applicable.

- XML format for data representation (optional!)
- global identification
- different specification usage in one document

# Blank nodes (BNodes)

As one can use only triples, we cannot represent `P(s,o1,o2,...)`. We have to split it on triples and join them via a **Blank Node** (BNode), which has no special IRI.




```
<http://example.org/web-data>
  dc:title "Web Data" ;
  ex:professor _:entity ;
  ex:students _:students ;
  ex:generatedBy _:activity1 .

_:entity
  ex:fullName "Alice Carol" ;
  ex:homePage <http://example.net/...
  ex:hasAddress _:address .

_:address
  a ex:Address ;
  ex:streetAddress "123 Main St." ;
  ex:postalCode "A1A1A1" ;
  ex:addressLocality "London" .

_:students
  a rdf:Bag ;
  ex:hasMember _:s1 ;
  ex:hasMember _:s2 .

_:activity1
  a ex:Event;
  ex:creator _:entity ;
  ex:atTime "Tuesday 11 February, 06:51:00 CST" .

_:activity2
  a ex:Event, ex:Update ;
  ex:actionOver _:activity1 ;
  ex:creator _:entity2 ;
  ex:atTime "Monday 17 February, 08:12:00 CST" .
```

# Data formats for graph representation

- N-Triples

```
<http://mythology.Greek.org/#Cronus>
    <http://www.example.org/schemas/relationship/fatherOf>
    <http://mythology.Greek.org/#Zeus>.
```

- Turtle

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dc: <http://purl.org/dc/elements/1.1/> .
@prefix ex: <http://example.org/stuff/1.0/> .
<http://www.w3.org/TR/rdf-syntax-grammar>
  dc:title "RDF/XML Syntax Specification (Revised)" ;
  ex:editor [
    ex:fullname "Dave Beckett";
    ex:homePage <http://purl.org/net/dajobe/>
  ] .
```

- Notation 3 (N3)

```
@prefix dc: <http://purl.org/dc/elements/1.1/> .
<http://en.wikipedia.org/wiki/Tony_Benn>
  dc:title "Tony Benn" ;
  dc:publisher "Wikipedia" .
```

- RDF/XML

```
<rdf:RDF
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:dc="http://purl.org/dc/elements/1.1/">
  <rdf:Description rdf:about="http://en.wikipedia.org/wiki/
    <dc:title>Tony Benn</dc:title>
    <dc:publisher>Wikipedia</dc:publisher>
  </rdf:Description>
</rdf:RDF>
```

- JSON-LD

```
{
  "@context": {
    "name": "http://xmlns.com/foaf/0.1/name",
    "homepage": {
      "@id": "http://xmlns.com/foaf/0.1/workplaceHomepage",
      "@type": "@id"
    },
    "Person": "http://xmlns.com/foaf/0.1/Person"
  },
  "@id": "http://me.markus-lanthaler.com",
  "@type": "Person",
  "name": "Markus Lanthaler",
  "homepage": "http://www.tugraz.at/"
}
```

# Resource storage and access

Semantic WEB documents are stored as **files**, **documents**, and, in general, [cloud] **resources** on servers.

Popular server software are

- Openlink Virtuoso (`DBPedia.org`)
- Apache Jena (also a Java library)
- GraphDB (has good control interface)
- ClioPatria (not so popular, has integrated Prolog engine)

**SPARQL** is a language to formulate questions (queries) for knowledge databases

```
SELECT ?publisher ?publisherLabel (AVG(?pages) AS ?avgPages)
WHERE
{
  ?book wdt:P123 ?publisher;
        wdt:P1104 ?pages.
  SERVICE wikibase:label { bd:serviceParam
        wikibase:language "[AUTO_LANGUAGE]". }
}
GROUP BY ?publisher ?publisherLabel
HAVING(COUNT(?book) > 1)
ORDER BY DESC(?avgPages)
```

Further info is at
`https://www.w3.org/wiki/SparqlImplementations`.

# Ontological instruments: ClioPatria

Places | Admin | CPACK | Repository | Query | Help | Login

Search

## Local view for "http://cliopatria.swi-prolog.org/schema/cpack#gitURL"

| Predicate | Value (sorted: default) |
|---|---|
| rdfs:label | "GIT URL" |
| rdf:type | owl:ObjectProperty |
| rdfs:domain | cpack:Software repository |
| rdfs:range | rdfs:Resource |
| rdfs:comment | "URL to clone the repository using git" |
| rdfs:subPropertyOf | cpack:SCM URL |

All properties reside in the graph http://cliopatria.swi-prolog.org/schema/cpack

The resource does not appear as an object

## Predicate statistics

| Predicate | #Triples | #Distinct subjects | #Distinct objects | Domain(s) | Range(s) |
|---|---|---|---|---|---|
| cpack:gitURL | 102 | 102 | 99 | 2 | rdfs:Resource |

## Context graph


cliopatria.swi-prolog.org/browse/list_graph?graph=http://cliopatria.swi-prolog.org/schema/cpack

# Semantic web technologies & Knowledge graphs

Semantic Web (WEB 3.0) is characterized with

- Technological basis, oriented to the web
- Standardized data formats, storage, and processing
- Open principles of data publishing
- Services for data storage and access provision
- Generalized and special user interfaces are used for data presentation

For the Knowledge Graphs (KG), the following is of interest.

- Converged notions **data** and **knowledge** as something is **known**
- Contain data, relations, and metadata (vocabularies)
- Distinguished **node filling in** and **processing** graph triples, *e.g.*, with SPARQL queries with UPDATEs
- Allow **postpone** the formal definition of a schema
- Three types of graph schemata: **semantic** (aimed at generalization), **validating** (**e.g.** semantics, **completeness** w.r.t. sets of relations), and **emergent** (infer a set of generalized structures and **reconstruct** the KG).

# Knowledge graph: Validating semantic example

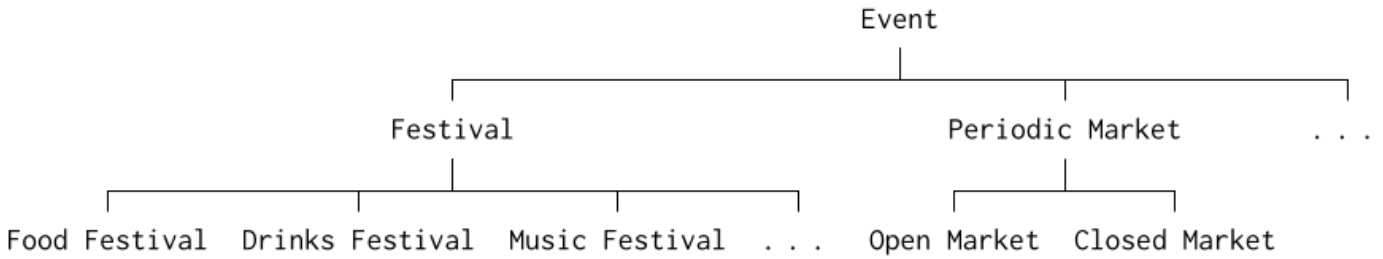



Fig. 10. Example class hierarchy for Event

Table 2. Definitions for sub-class, sub-property, domain and range features in semantic schemata

| Feature | Definition | Condition | Example |
|---|---|---|---|
| SUBCLASS | (c) –subc. of→ (d) | (x) –type→ (c) implies (x) –type→ (d) | City –subc. of→ Place |
| SUBPROPERTY | (p) –subp. of→ (q) | (x) –p→ (y) implies (x) –q→ (y) | venue –subp. of→ location |
| DOMAIN | (p) –domain→ (c) | (x) –p→ (y) implies (x) –type→ (c) | venue –domain→ Event |
| RANGE | (p) –range→ (c) | (x) –p→ (y) implies (y) –type→ (c) | venue –range→ Venue |

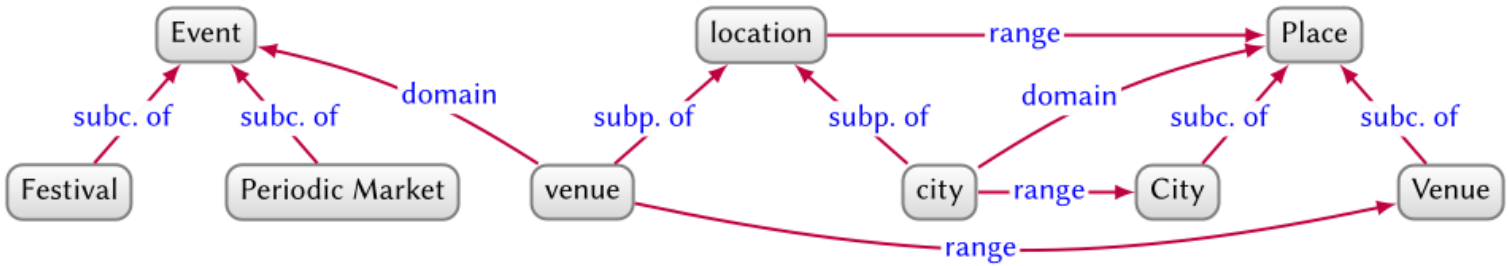



Fig. 11. Example schema graph describing sub-classes, sub-properties, domains, and ranges

# Linked Open Data (LOD) star evaluation

Data are available in

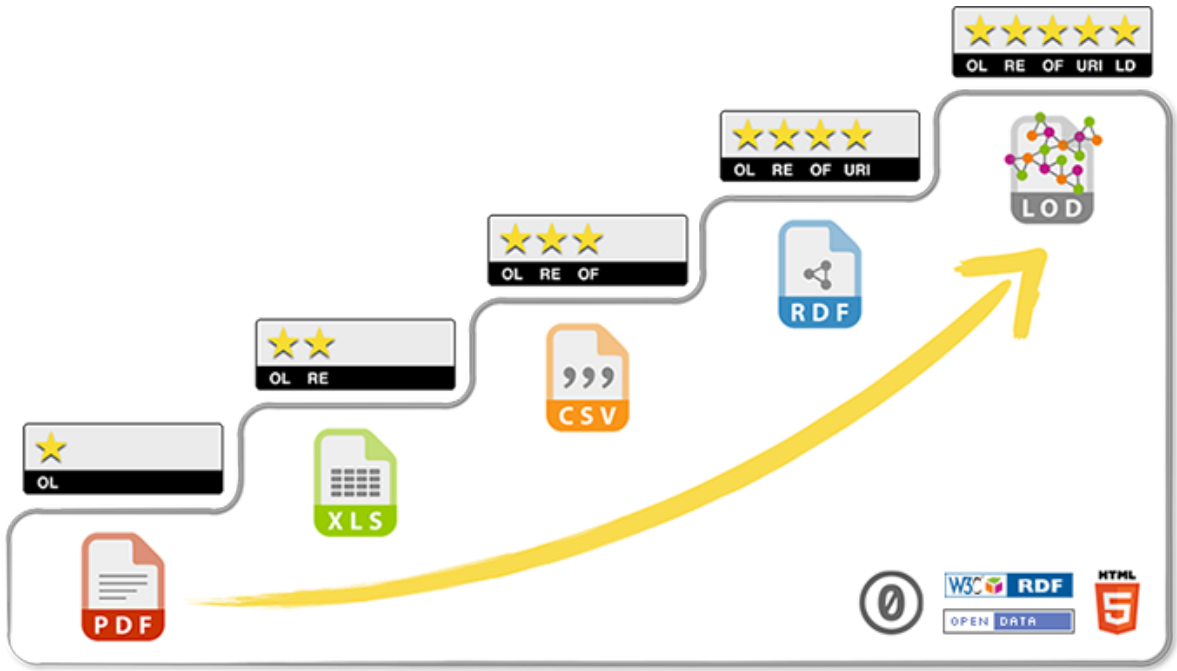
1* any format **openly**

2* a **structured format**, such as Microsoft Excel file format (.xls)

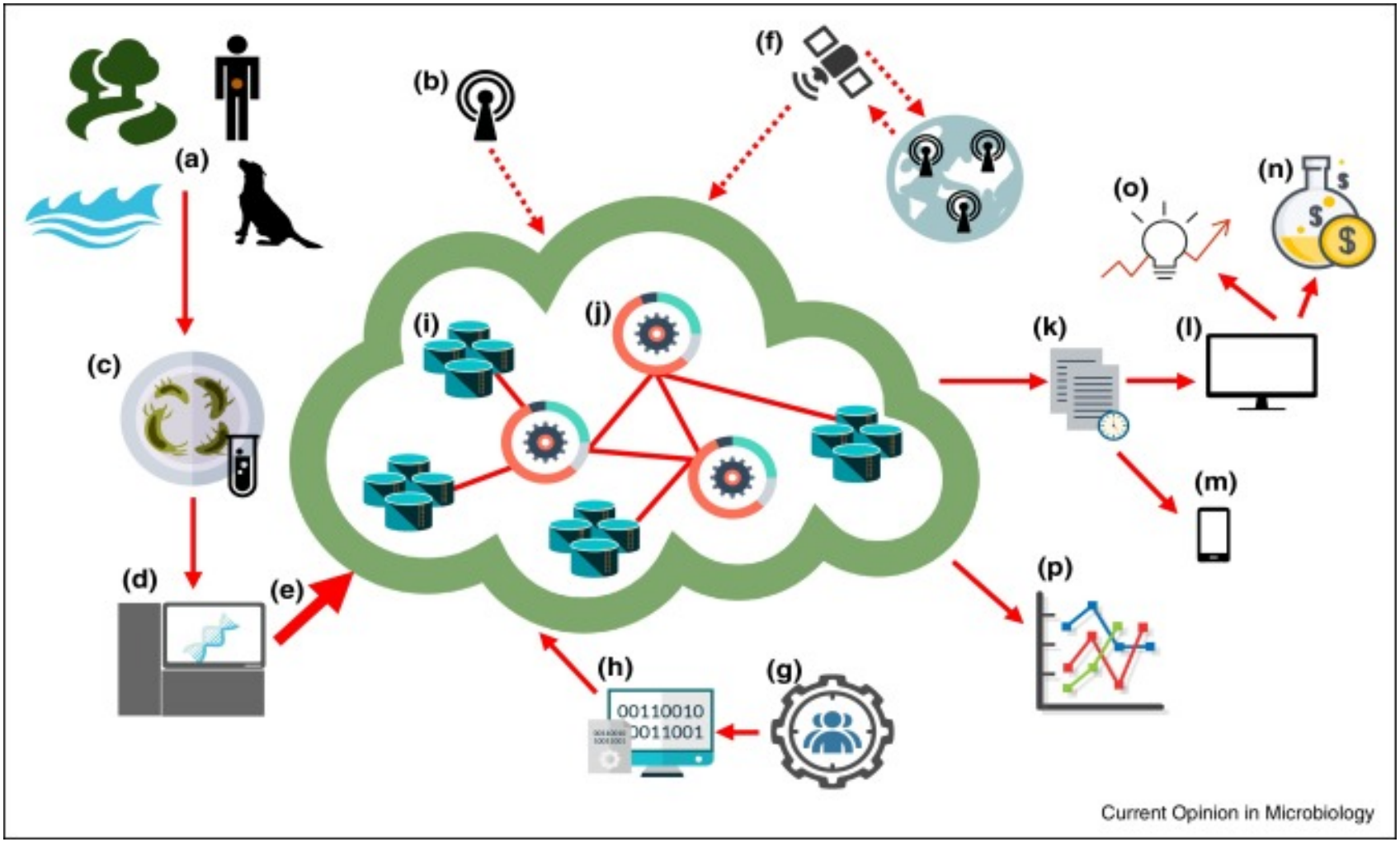
3* a **non-proprietary structured format**, such as .csv

4* **W3C standards**, like using RDF and employing URIs

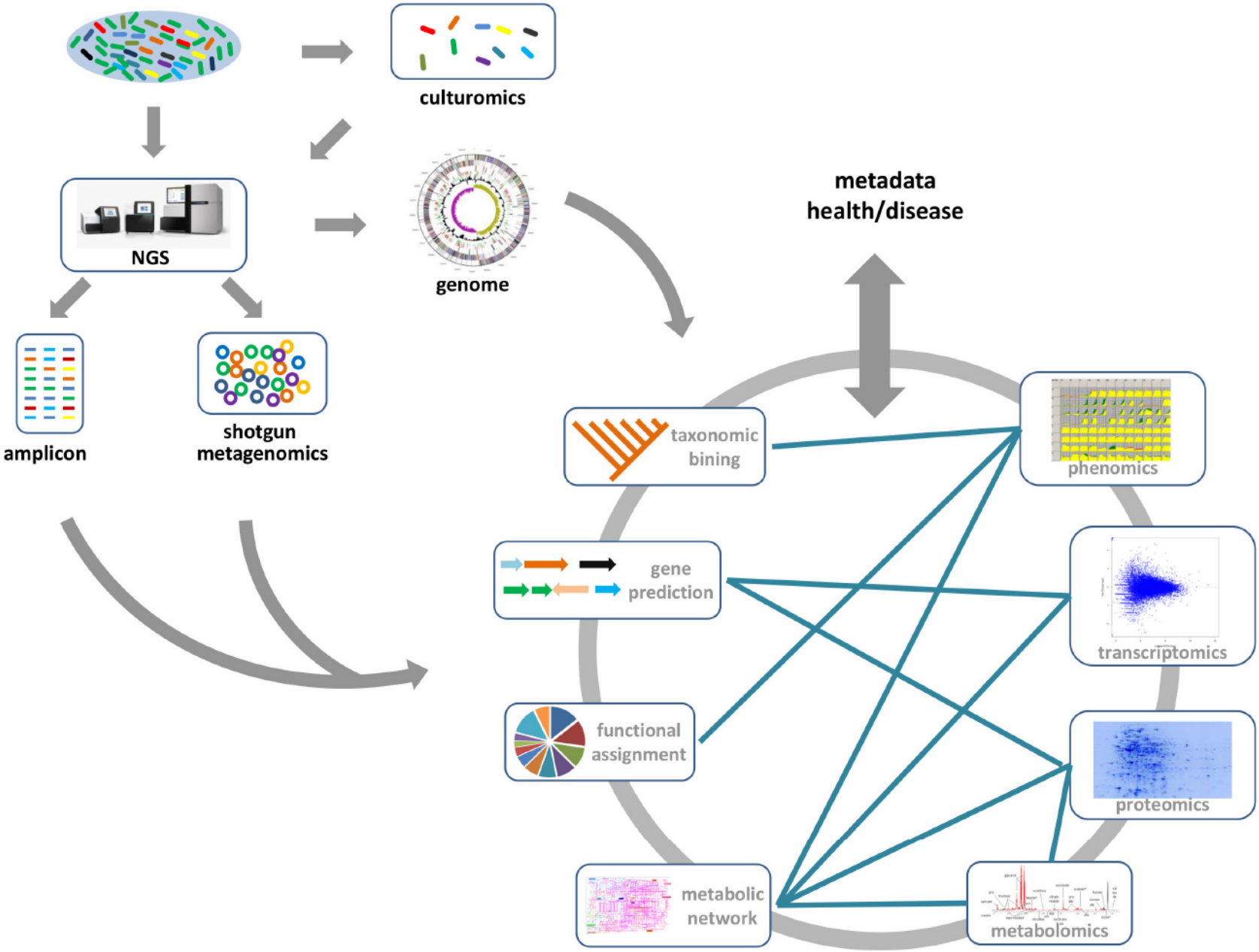
5* a hypercontent form **having links to other Linked Open Data sources**



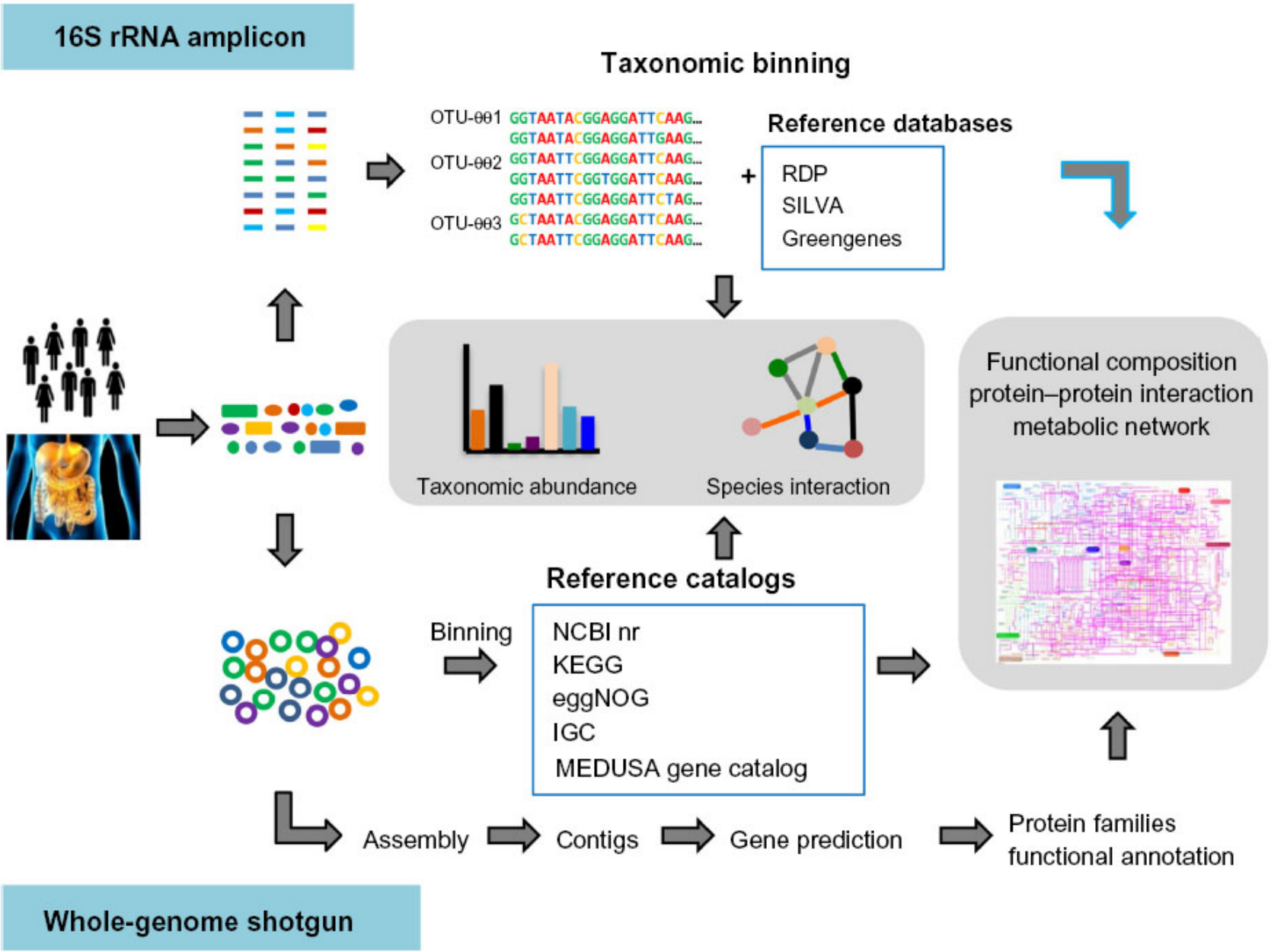
# Information infrastructure for supporting Baikal microbiome research



# Microbiome study aims



# Microbiome study process



# The aim of the research and development

The object of the research is genetic data processing. We would like to involve biologists in it. The subject is the amplicon data processing with MiSeq SOP[1] (a technique).
The primary **aim** of the research is to construct infrastructure which comprises

- Big Data database for sequence storage;
- metadata storage and adapters;
- visual construction of a processing model;
- cloud genetic data processing unit;
- metadata inference unit;
- data integration unit based on Semantic Web and Linked Open Data principles.

[1] Standard Operational Procedure

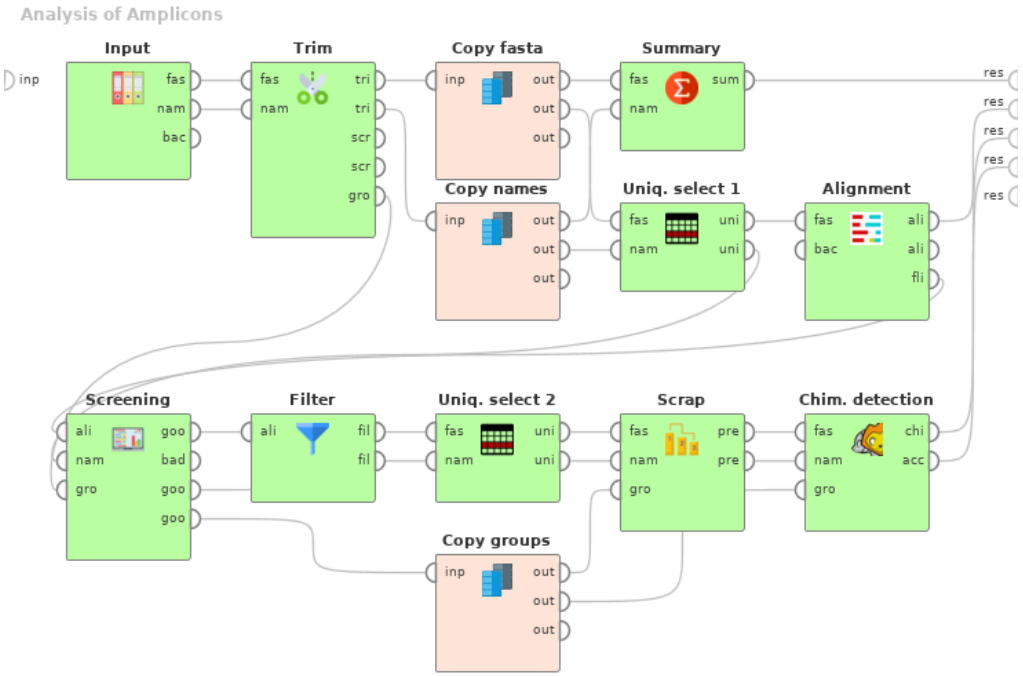
# The process of data analysis (MiSeq SOP)

1. Reconstruct *cotigs* (contiguous gene parts) from “left” and “right” *readings*.
2. Trim **bar-code** and other *primers*.
3. Filter sequences according to formal criteria (ambiguity, average length, maximal length of homopolymer).
4. Classify *unique* sequences and count their appearance in groups (samples).
5. Alignment with reference sequences from SILVA database.
6. Filter non-hanging sequences.
7. Filter chimeras, fund unique sequences again.
8. Classify sequences with respect to existing taxa hierarchy. Get **OTU**s.

After these stages a large number of OTU[2] classified has been obtained.

[2] Operation Taxonomic Unit

# Dataflow representation of NGS analysis of amplicons




| Term | Description |
|---|---|
| NGS | New Generation Sequencing |
| Amplicon | A DNA or RNA part copied many times |
| Mothur | A software toolset for NGS research |
| Rapidminer | A visual tool for data mining modeling and execution |

Green blocks are Mothur modules.
Others are Rapidminer modules.

# Rapidminer module

```
...vector<string> AlignCommand::setParameters(){ // PART OF MODULE SOURCE
try {
 CommandParameter ptemplate("reference", "InputTypes", "", "", "none", "none", "none","",false,true,true); parameters.push_back(ptemp
 CommandParameter pcandidate("fasta", "InputTypes", "", "", "none", "none", "none","fasta-alignreport-accnos",false,true,true); param
 CommandParameter psearch("search", "Multiple", "kmer-blast-suffix", "kmer", "", "", "","",false,false,true); parameters.push_back(ps
 CommandParameter pksize("ksize", "Number", "", "8", "", "", "","",false,false); parameters.push_back(pksize);
 CommandParameter pmatch("match", "Number", "", "1.0", "", "", "","",false,false); parameters.push_back(pmatch);
// . . . . . .
```

```
package com.rapidminer.ngs.operator; // GENERATED JAVA MODULE
// imports

class MothurChimeraCcodeOperator extends MothurGeneratedOperator {
  private InputPort fastaInPort = getInputPorts().createPort("fasta");
  private InputPort referenceInPort = getInputPorts().createPort("reference");
  private OutputPort chimeraOutPort = getOutputPorts().createPort("chimera");
  private OutputPort mapinfoOutPort = getOutputPorts().createPort("mapinfo");
  private OutputPort accnosOutPort = getOutputPorts().createPort("accnos");

  public MothurChimeraCcodeOperator (OperatorDescription description) {
    super(description);
  }
  @Override
  public void doWork() throws OperatorException {
    super();
    // . . . . . .
  }
  @Override
  public String getOutputPattern(String type) {
    if (type=="chimera") return
 "[filename],[tag],ccode.chimeras-[filename],ccode.chimeras";
    if (type=="mapinfo") return "[filename],mapinfo";
    if (type=="accnos") return
 "[filename],[tag],ccode.accnos-[filename],ccode.accnos";
    return super.getOutputPattern(type);
  }
}
```

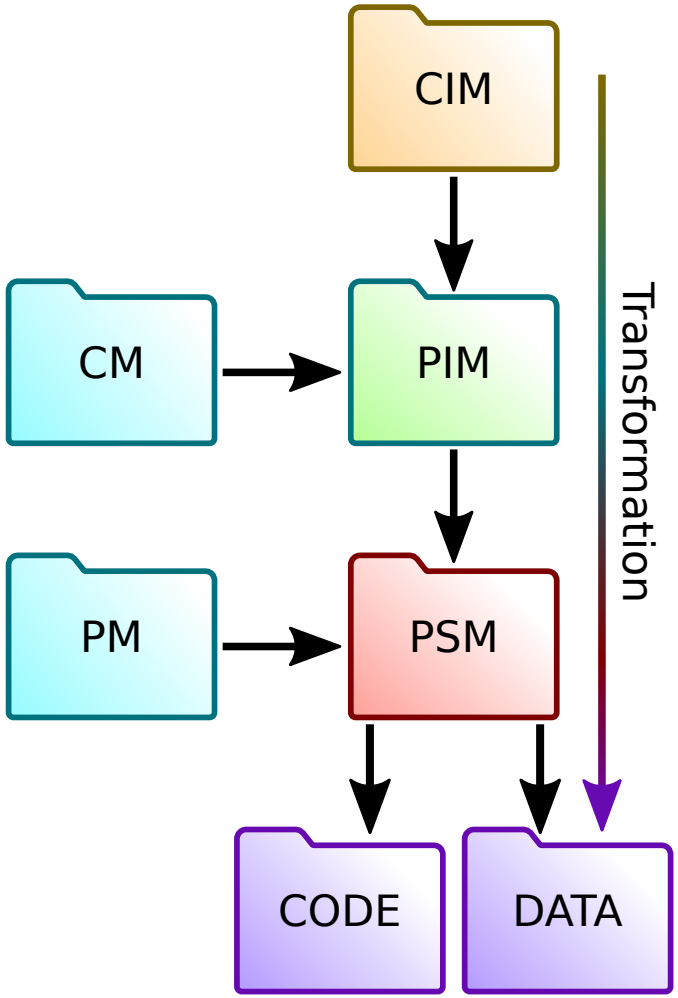
```
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
ngsp:spec a ngsp:Specification ;
    ngsp:module mothur:NoCommand,
        mothur:align-check,
        mothur:align-seqs,
# . . . . .
mothur:align-check a ngsp:Module ;
    ngsp:outputPattern [ a cnt:Chars ;
            ngsp:parameterName "type" ;
            ngsp:pattern [ ngsp:patternString
                    "[filename],align.check" ;
                    dc:identifier "aligncheck" ] ;
            cnt:chars # . . . .
# . . . . .
mothur:align-check-idir-parameter a ngsp:Parameter ;
    ngsp:important false ;
    ngsp:multipleSelectionAllowed false ;
    ngsp:optionsDefault "" ;
    ngsp:required false ;
    ngsp:type mothur:String ;
    dc:title "inputdir" .

mothur:align-check-map-parameter a ngsp:Parameter ;
    ngsp:important true ;
    ngsp:multipleSelectionAllowed false ;
    ngsp:optionsDefault "" ;
    ngsp:required true ;
    ngsp:type mothur:InputTypes ;
    dc:title "map" .
# . . . . .
```

# Procedural data (Mothur tooling of Galaxy)

```
<tool profile="16.07" id="mothur_make_contigs"
  name="Make.contigs" version="@WRAPPER_VERSION@.0">
  <description>Aligns paired ...</description>
  <!- . . . . ->
  <command><![CDATA[ @SHELL_OPTIONS@
## Symlinks creation or On the fly ...
#if input_type.type == 'list_collection'
  #for pair in input_type.list_paired_collection:
    ln -s {pair.forward} `basename {pair.forward}` &&
    ln -s {pair.reverse} `basename {pair.reverse}` &&
    echo -e "{pair.name}\t`basename {pair.forward}`\t
    `basename {pair.reverse}`" » combo_fastq.dat &&
  #end for ## . . . . . .
echo 'make.contigs(
  #if input_type.type == 'list_collection':
    file=combo_fastq.dat,
  #else:
    ffastq=ffastq.dat,
    rfastq=rfastq.dat,
  #end if  ## . . . . . .
  gapextend=gapextend,
  rename=rename
  processors='{GALAXY_SLOTS:-8}'
)' | sed 's/ //g' | mothur | tee mothur.out.log
  ]]></command>
  <inputs>
    <conditional name="input_type">
      <param name="type" type="select" label="Select ...">
        <option value="regular" selected="true">Two ...</option>
        <option value="simple_collection">One pair ...</option>
        <option value="list_collection">Multiple ....</option>
      </param>
      <when value="regular">
        <param name="forward_fastq" type="data" />
        <param name="reverse_fastq" type="data" />
      </when>
    </conditional>
    <param name="align" type="select" label="...." help="">
```

```
@prefix dc: <http://purl.org/dc/elements/1.1/> .

[] a gal:Suite ;
 ngsp:module [ a gal:Module,
     ngsp:Module ;
   gal:command " ## . . . .  ";
   gal:exit_code [ gal:level "fatal" ;
     gal:range "1:" ] ;
       gal:inputs [ gal:checked "false" ;
         gal:conditional [ gal:param [ gal:help "" ;
           gal:option [ gal:value "yes" ;
              dc:description "yes" ],
                [ gal:value "no" ;
                  dc:description "no" ] ;
                dc:description "Trim with an oligos file?" ;
                dc:title "add" ;
               rdfs:range "select" ] ;
             gal:when [ gal:value "no" ],
             [ gal:param [ gal:min "0" ;
               gal:value "0" ;
               dc:description "pdiffs - number of differences to all
               dc:title "pdiffs" ;
               rdfs:range "integer" ],
               [ gal:min "0" ;
                 gal:value "0" ;
                 dc:description "bdiffs - number of differences to a
                 dc:title "bdiffs" ;
                 rdfs:range "integer" ],
               [ gal:min "0" ;
                 gal:value "0" ;
                 dc:description "tdiffs - total number of difference
               dc:title "tdiffs" ;
               rdfs:range "integer" ] ] ] ]
   dc:identifier "mothur_make_contigs" ;
   dc:title "Make.contigs",
            "make.contigs" ;
   schema:sku 1 ''
```

# Model–Driven Architecture




CIM Computationally Independent Model;

CM Model of Computations;

PIM Platform Independent Model;

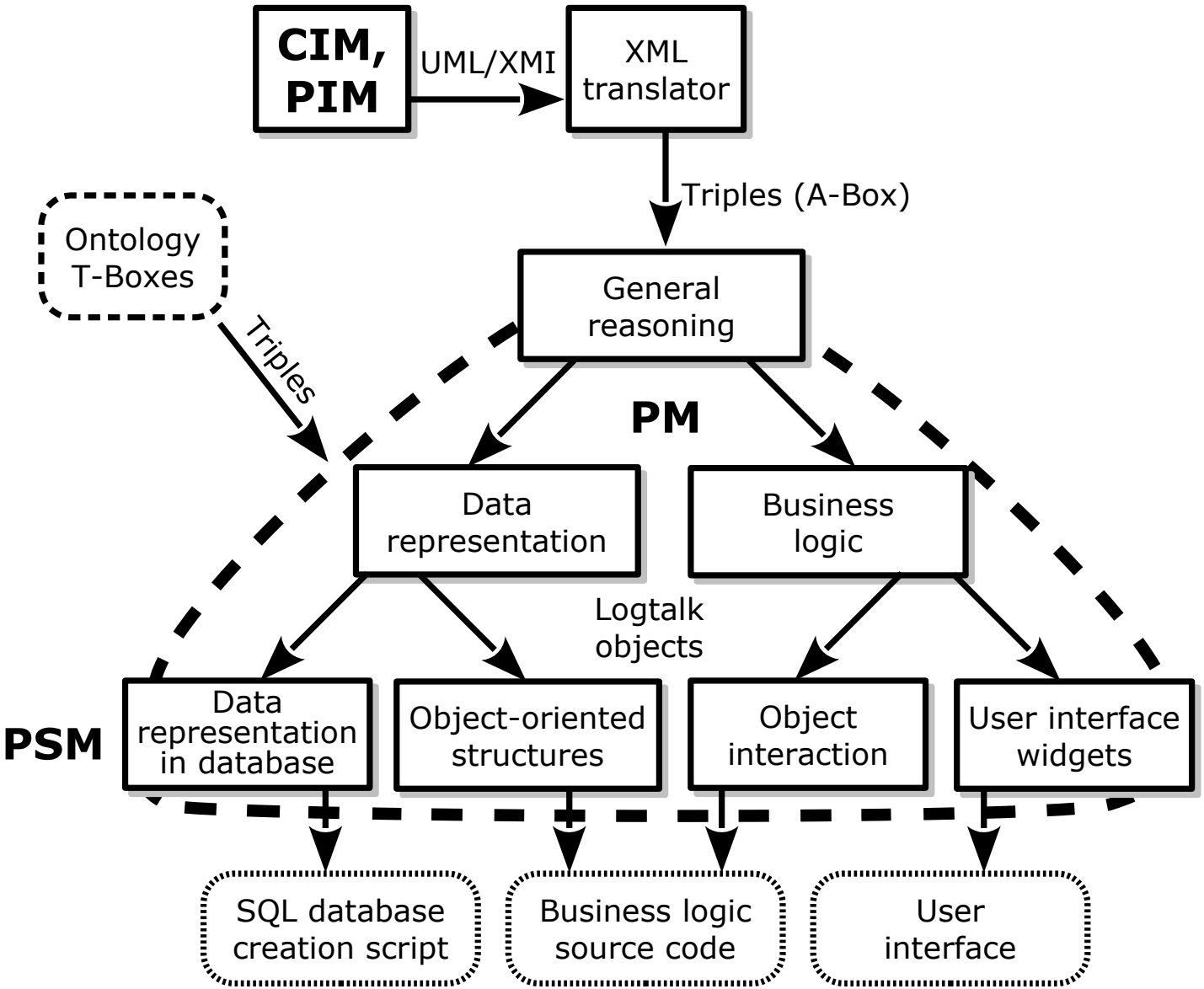
PM Platform Model;

PSM Platform–Specific Model;

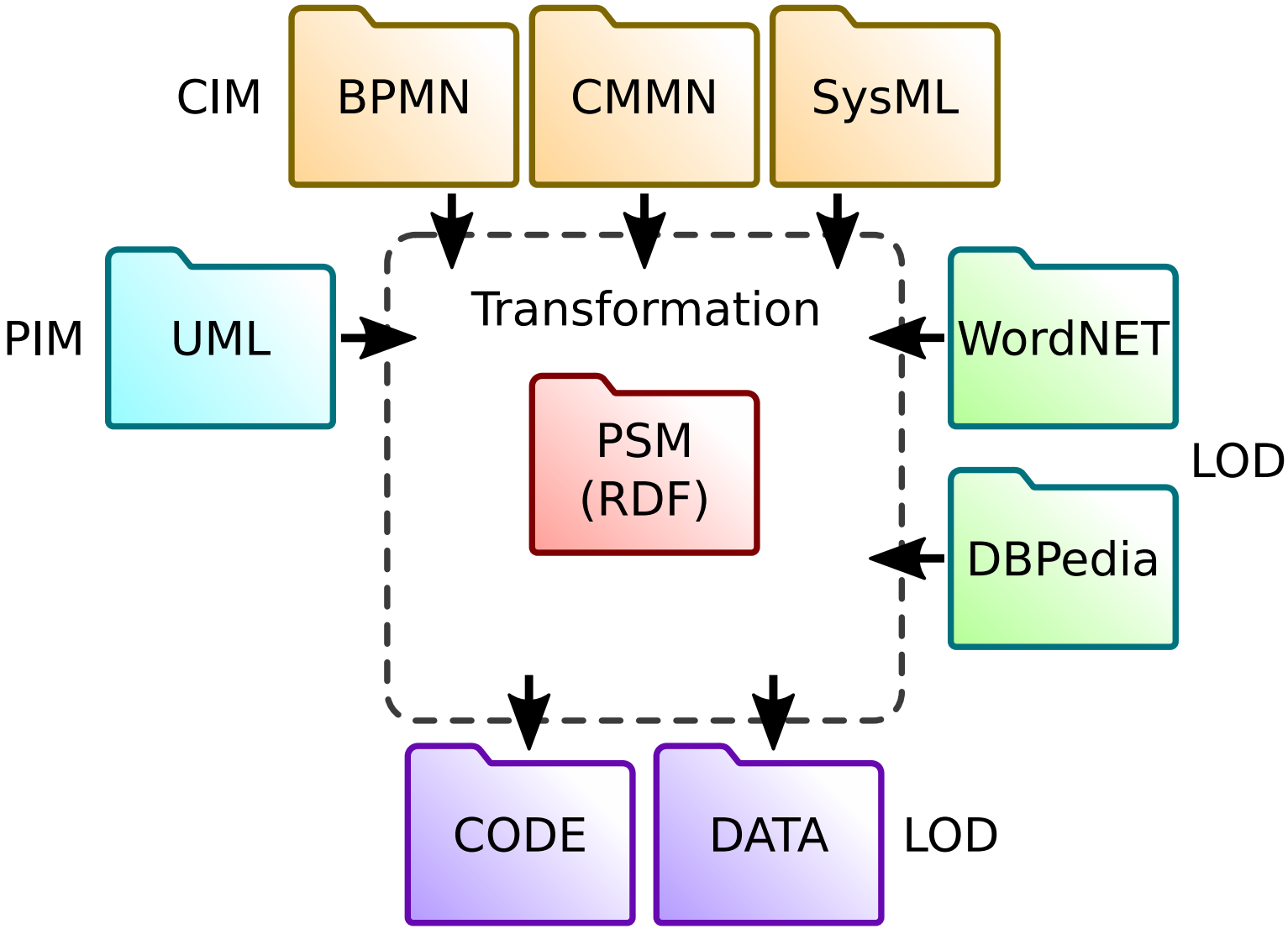
CODE Source code of software;

DATA Initial database state.

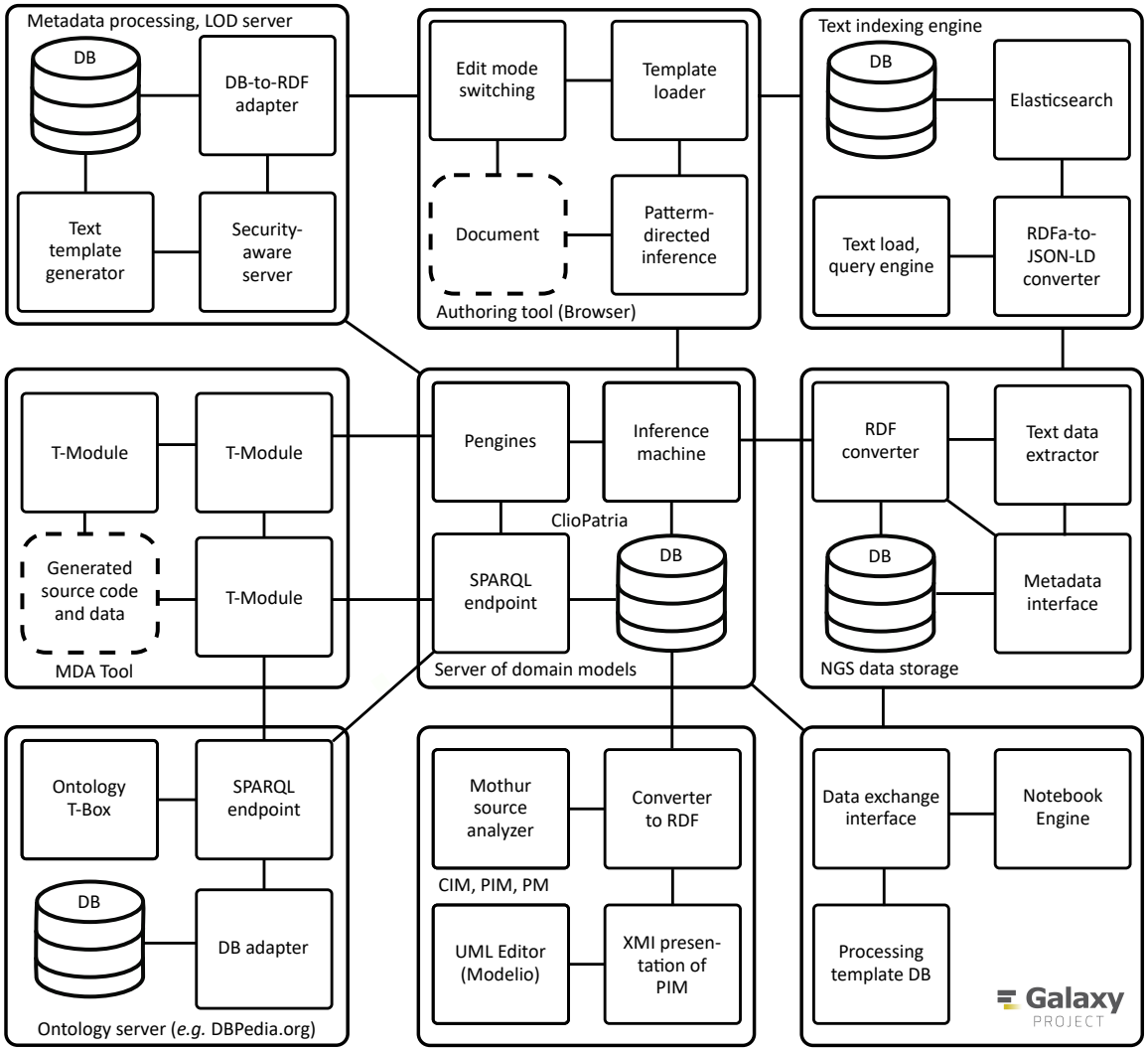
# Architecture of transformation modules



# Model Driven Architecture and Linked Open Data



# Architecture of services




## Abbreviations

T-Module is Transformation module
MDA is Model-Driven Architecture
CIM is Computationally Independent Model
PIM is Platform Independent Model
PSM is Platform Specific Model
T-Box is Terminological Box
A-Box is Instance Box
A-Box is Instance Box
NGS is Next-Generation Sequencing
DB is Database

# Used ontologies

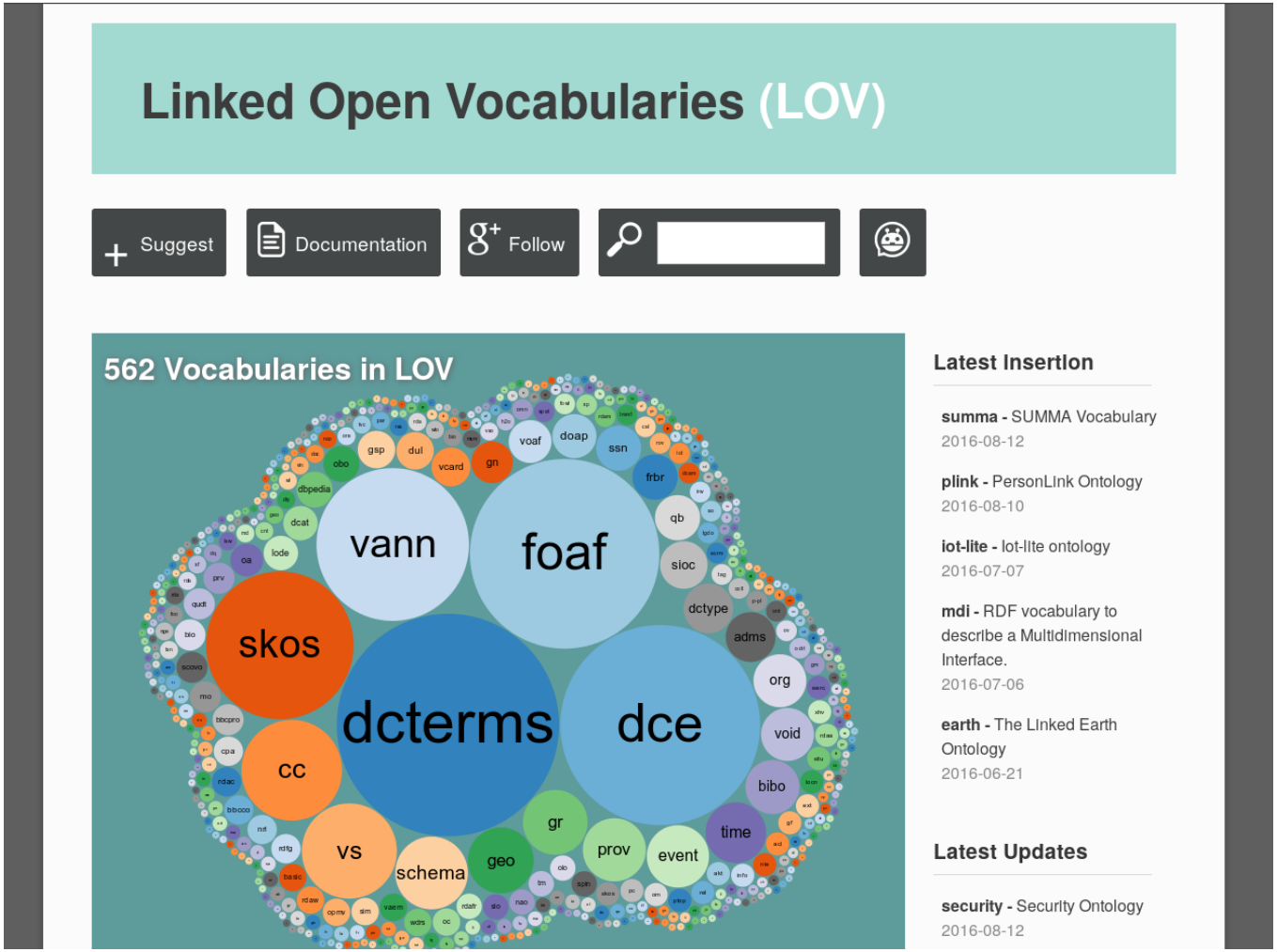
Standardized ontologies

- Friend-of-a-friend (**foaf**) for agent information: individuals, legal entities, program agents.
- Provenance (**prov**) for making references between documents.
- Dublin Core (**dc**) for published resource metadata mark up.
- DBPedia resource (**dbr**) to refer external classes and instance objects.
- Schema.org (**schema**) for Google, Yandex, Yahoo, *etc.* searchable objects, structural elements.
- The Bibliographic Ontology (**bibo**) used for literature reference mark up.
- Open annotation (**oa**) as an “bookmark” ontology.

Non-standard ontologies

- Ontology **nssp** for Mothur source code processing results.
- Ontology **uml** for XMI representation.

# Instrumentation: Ontology metadata server LOV



# Logtalk as transformation definition language

We have chosen Logtalk as it

- inherits widely known Prolog language syntax and runtime;
- implemented as macro package, performance penalties are about 1.5%;
- has flexible semantics: we can define transformations and constraints within the same syntax;
- implement object-oriented knowledge (rules) structuring, encapsulation and replacement;
- compositional way of transformation implementation;
- powerful engine to post constraints on object-to-object messages (events);
- has implementation for many Prolog engines.

The «regular» language allow us to use its libraries not directly related to MDA transformations.

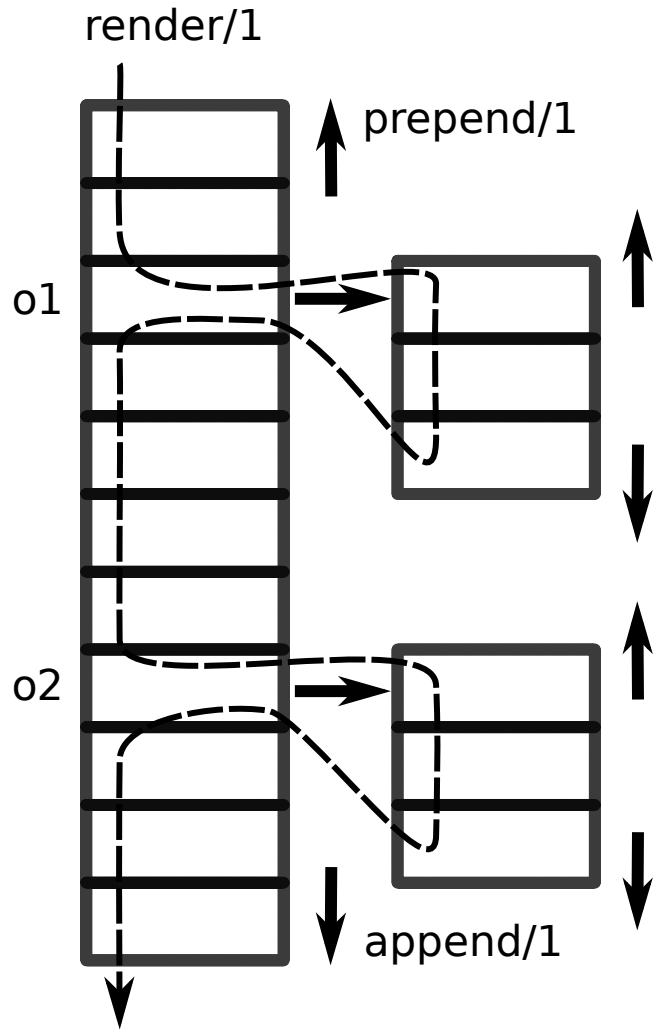
# RDF (TTL) representation and and its query object

```
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
ngsp:spec a ngsp:Specification ;
    ngsp:module mothur:NoCommand,
        mothur:align-check,
        mothur:align-seqs,
# . . . . .
mothur:align-check a ngsp:Module ;
    ngsp:outputPattern [ a cnt:Chars ;
            ngsp:parameterName "type" ;
            ngsp:pattern [ ngsp:patternString
                    "[filename],align.check" ;
                    dc:identifier "aligncheck" ] ;
            cnt:chars # . . . .
# . . . . .
mothur:align-check-idir-parameter a ngsp:Parameter ;
    ngsp:important false ;
    ngsp:multipleSelectionAllowed false ;
    ngsp:optionsDefault "" ;
    ngsp:required false ;
    ngsp:type mothur:String ;
    dc:title "inputdir" .

mothur:align-check-map-parameter a ngsp:Parameter ;
    ngsp:important true ;
    ngsp:multipleSelectionAllowed false ;
    ngsp:optionsDefault "" ;
    ngsp:required true ;
    ngsp:type mothur:InputTypes ;
    dc:title "map" .

mothur:align-check-name-parameter a ngsp:Parameter ;
    ngsp:chooseOnlyOneGroup "namecount" ;
    ngsp:important false ;
    ngsp:multipleSelectionAllowed false ;
# . . . . .
```

```
:- object(query(_XMI)).
:- protected(xmi/1).
:- public([class/2, attribute/3, method/3]).
xmi(XMI) :- parameter(1, XMI).
    % Recognition of Class in RDF
class(Name, ID):-
    ::xmi(XMI),
    XMI::rdf(ID,rdf:type,uml:'Class'),
    XMI::rdf(ID,rdfs:label, literal(Name)).
    % Recognition of an attribute
attribute(Name, ClassID, ID):-
    ::xmi(XMI),
    XMI::rdf(ClassID, xmi:ownedAttribute, ID),
    XMI::rdf(ID, rdfs:label, literal(Name)).
    % Recognition of a method specification.
method(Name, ClassID, ID):-
    ::XMI(XMI),
    XMI::rdf(ClassID, xmi:ownedOperation, ID),
    XMI::rdf(ID, rdfs:label, literal(Name)).
% . . . . . .
:- end_object.
```

# Code Block (idea is taken from `llvmlite`*)

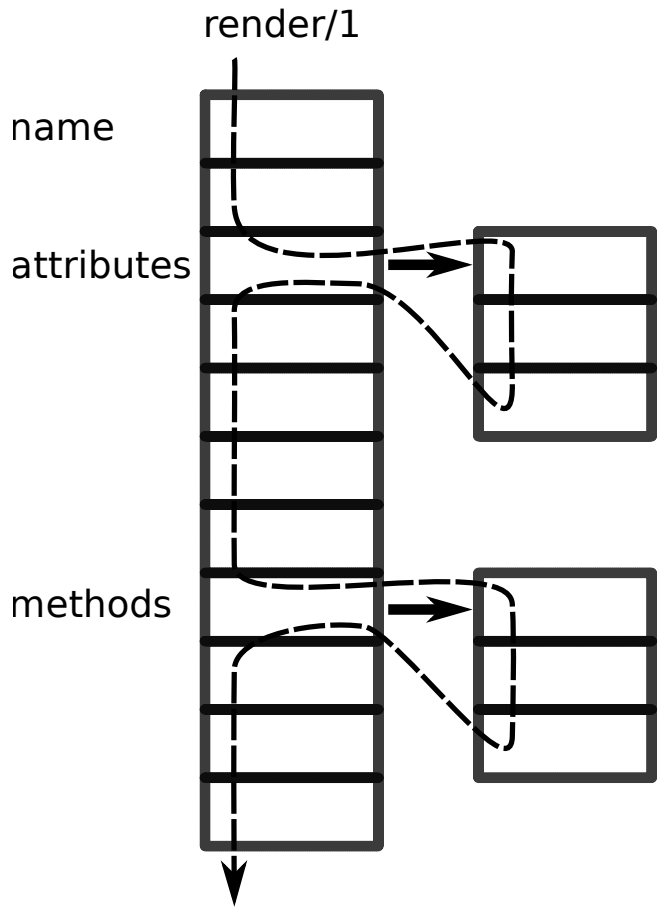
```
:- object(code_block, specializes(root)).
% Public interface of the object
:- public([append/1, prepend/1, clear/0,
    render/1, render_to/1, remove/1,
    item/1, items/1]).
% Code block items
:- dynamic([item_/1]).
:- private([item_/1]).
% Methods specialized during inheritance
:- protected([renderitem/2, render_to/2]).
% . . . . . .
% Delegate rendering to object itself
renderitem(Object, String):-
    current_object(Object), !,
    Object::render(String).
% Convert a literal to its string
% representation
renderitem(literal(Item), String):-!,
    atom_string(Item, String).
% Just print the item (debugging).
renderitem(Item, String):-
    root::iswritef(String, '%q', [Item]).
:- end_object.
```




*) https://github.com/numba/llvmlite

# PSM of a Python Class as a specialization of Code Block

```
:- object(class, specializes(code_block),
   imports([named])). % Category of named entities
:- public([classlist/1, methods/1, attributes/1]).
% . . . . . .
renderitem(Item, Result):-      % proceed with default
    ^^renderitem(Item, Result). % rendering
render(Result):-          % Source generator
    ^^render(Name),       % implemented in a category
    ( ::item(classlist(List)) ->
     % . . . . . .
        [Name]) ),
    ( ::item(attributes(Attributes))->
     % . . . . . .
        [DefAttrList]),
      Attributes::items(InstanceAttrs),
      findall(S, ( % initialize attributes
         % . . . . . .
         ), AttrAssigns),
        root::unindent,
        AttrList=[ConstructorDef|AttrAssigns];
         % . . . . . .
        AttrList=[ConstructorDef, Pass] ),
    ( ::item(methods(Methods))-> % If any ...
      Methods::render(MethodList);
      MethodList=[] ),
    lists::append(AttrList,MethodList,StringList),
    root::unindent, Result=[Signature|StringList].
:- end_object.
```



# Logtalk Categories

## A category of named entities

```
:- category(named).
:- public([name/1, render/1]).
:- protected([renderitem/2]).
name(Name):- ::prepend(name(Name)).
renderitem(name(Name), String):-!, atom_string(Name, String).
render(String):-  % What is code generation from items
    ::item(name(Name)), ::renderitem(name(Name), String).
:-end_category.
```

## Category of named and typed entities

```
:- category(namedtyped, extends(named)).
:- public([type/1,render/2, separator_option/2,list_separator/1]).
:- protected([renderitem/2]).
type(Type):- ::append(type(Type)).
renderitem(Item, String):- ^^renderitem(Item, String),!.
renderitem(type(Type),String):-!, ::list_separator(Separator),
    writef::swritef(String, '%w%w', [Separator, Type]).
render(Middle, String):- ^^render(SName),
    (   ::item(type(Type)) ->
        ::renderitem(type(Type), SType),
        string_concat(SName, Middle, _1),
        string_concat(_1, SType, String) ;
        SName = String  ).
render(String):-  ::render("", String).
list_separator(Separator):-
    ::separator_option(Name, Default),!, % Global options
    root::option(Name, Separator, Default).
:- end_category.
```

# Discussion (MDA application)

Interesting positive impressions obtained:

- Logtalk and RDF are flexible, sufficiently universal and convenient implementation infrastructures for MDA;
- The best implemenation means is Prolog predicate wrapping and Logtalk object encapsulation of rules;
- Not all Logtalk properties are investigated: there might be more sophisticated programming techniques developed, *e.g.*, on the base of message watchers.

Technical problems making the approach somewhat problematic:

- Very simple tasks take too much efforts, *e.g.*, text processing: convert an identifier into the CamelCase;
- It takes too long to surf Internet in order to find a vocabulary for a domain, but it is more productive than development new one and classes;
- Prolog is not a popular language in MDA, neither Logtalk.

# Future activities

The future activities supposed to be as follows:

1. Having dataflow models of MiSeq SOP and other techniques, device an intelligent subsystem, which will construct computational procedures for a predefined set of data processing tasks (*AI's problem solving*).
2. Integrate dataflow and data storage with Galaxy.
   - Realize adapters of data/metadata storage and retrieving, as well as the storage.
   - Create a more sophisticated source code parser or PIM model of computation so we will able to infer metadata for the output on the metadata of input (partially done in November).
   - Adapt our document authoring tools to Galaxy allowing LOD representation of results.
3. Implement integration to biological/gene databases.
4. Write a handbook on Logtalk programming strategies with its author Paulo Mora.

# Discussion (MDA application)

Interesting positive impressions obtained:

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# Document authoring and storage

In most cases documents are created as a result of

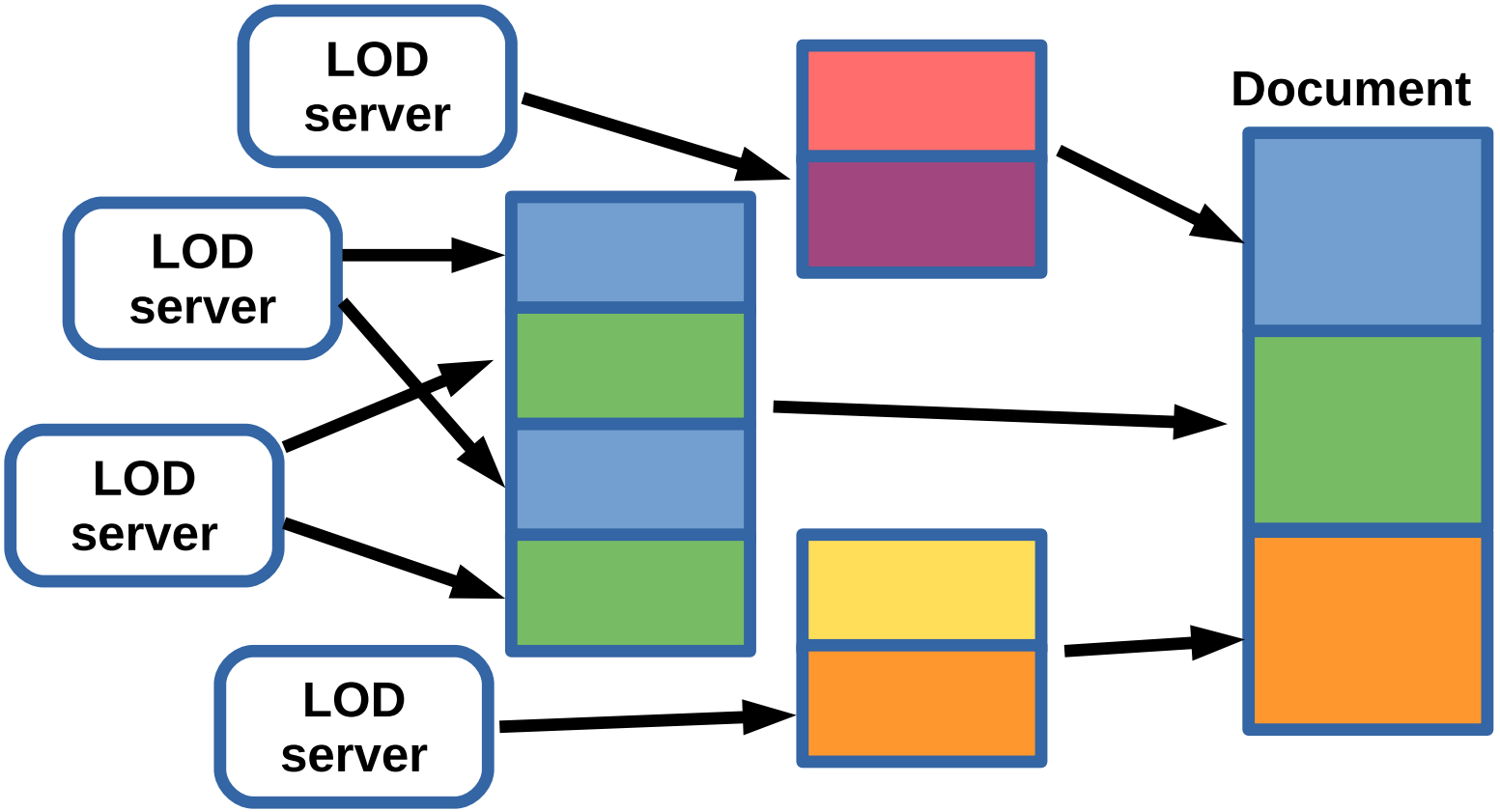
- creative activity of a person with a text processors (authoring);
- printing a digital copy or a data record in a database;
- aggregation operation over database records (report).

Then it is stored either as a physical paper and/or a digital document (PDF, DOCX, HTML).
Since 2000-th, Semantic Web and Linked Open Data (LOD) is being developed, allowing

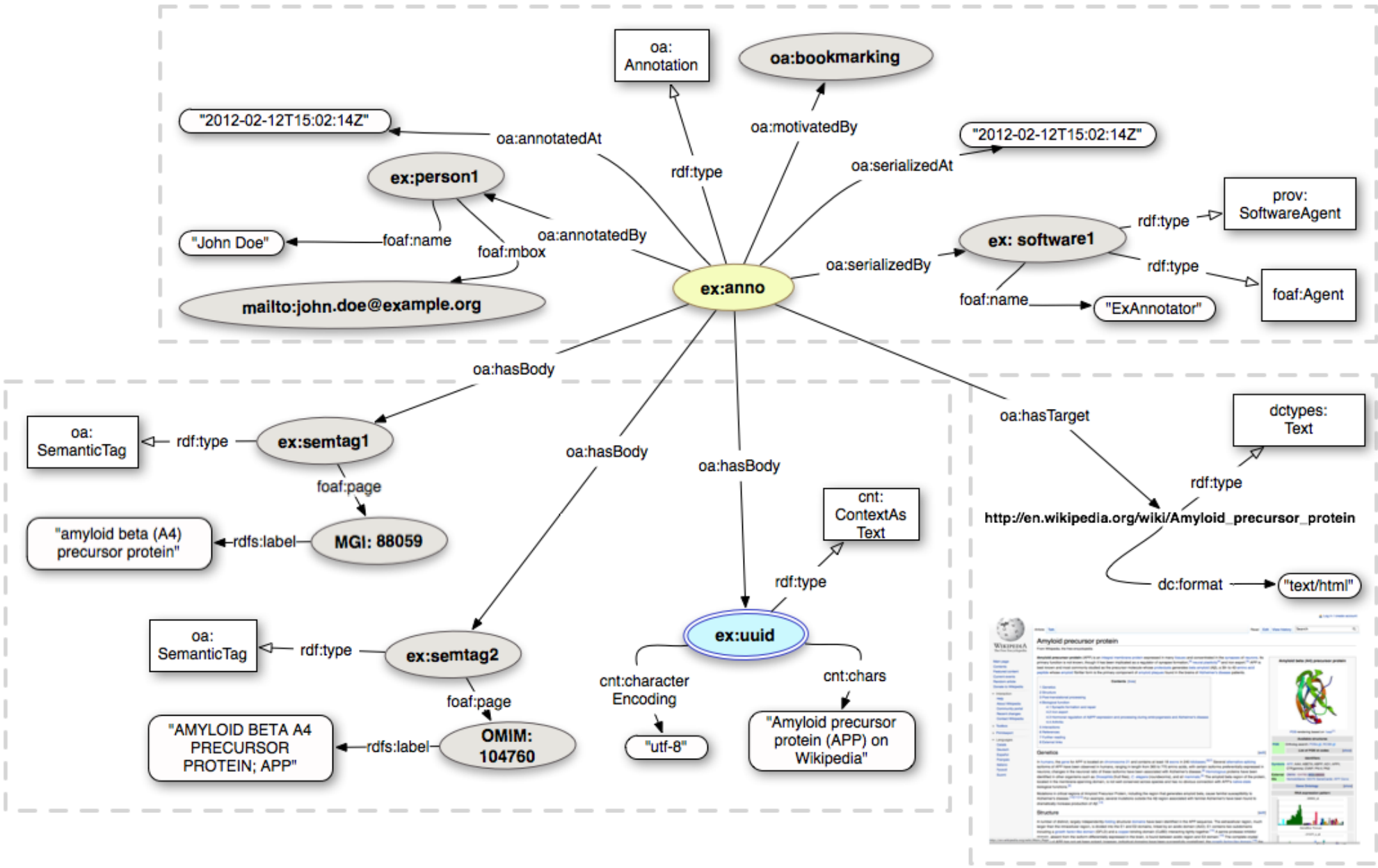
- structural storage of data within published documents;
- processing stored data computationally;
- integration of data structures and data objects globally.

The **aim of this research** is to develop technologies, software and services allowing construction of digital archives supporting document data inclusion and inference from existing documents.

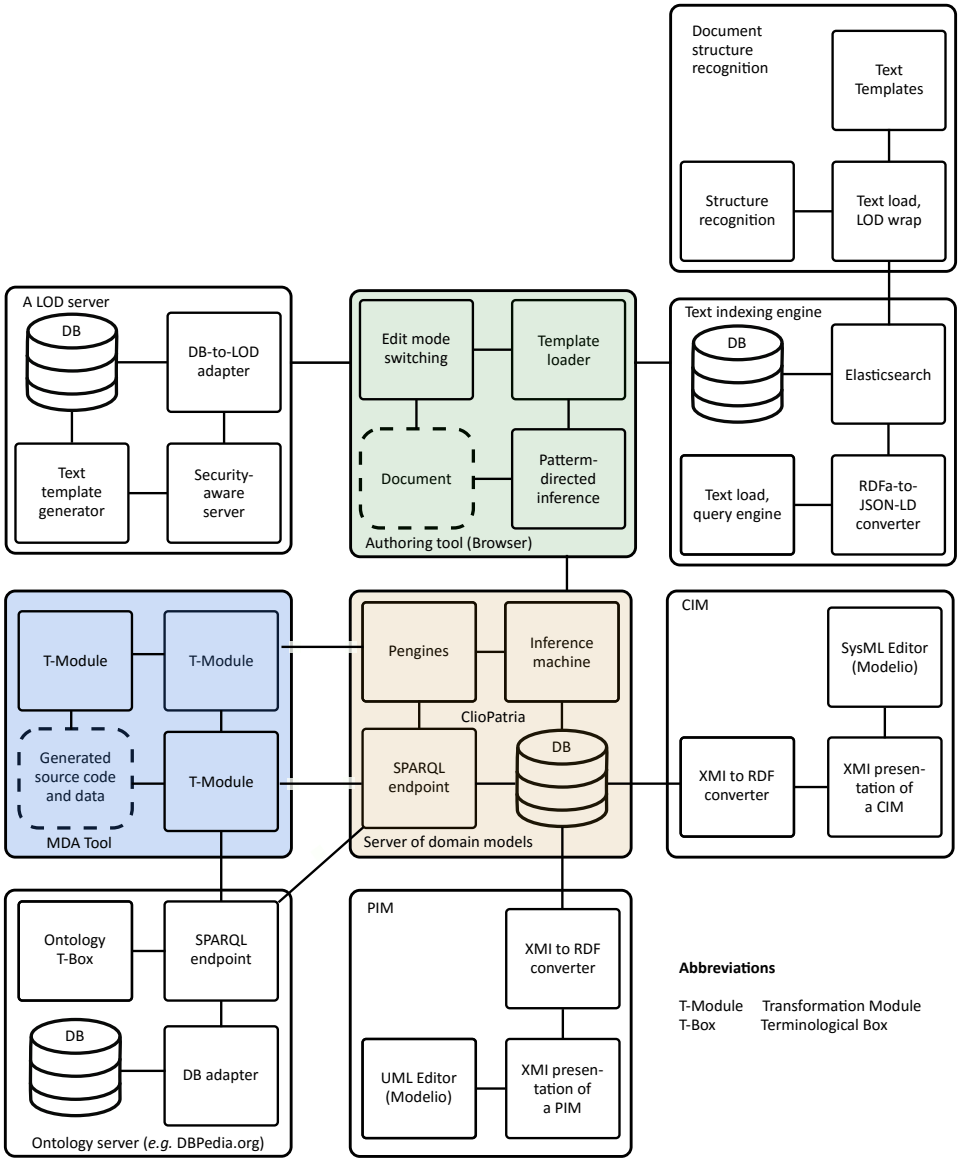
# Structure of a document



# Open Annotation (oa)



# Architecture



# Generated list of title page preambles

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ
федеральное государственное бюджетное образовательное учреждение высшего образования
«ИРКУТСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ»
ФГБОУ ВО «ИГУ»
Институт математики экономики и информатики

Кафедра информационных технологий

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Институт математики экономики и информатики

Кафедра алгебраических и информационных систем

УТВЕРЖДАЮ

# Generated part of a study program

**Учебный план специальности**
**01.03.02 Прикладная математика и информатика**

## 1. Общие сведения учебного плана

**Сведения по Учебному плану**
Профиль подготовки: Математическое и компьютерное моделирование в технике и экономике, методы принятия решений
**Сведения о кафедре, разработавшей Учебный план**
Кафедра: Математического анализа и дифференциальных уравнений,
Факультет: ИМЭИ.
**Сведения о специальности**
Квалификация: Бакалавр
Форма обучения: очная
Программа подготовки: прикладн. бакалавриат
**Руководители**
Проректор по учебной работе: Не распознан
Начальник УМУ: А.И. Вокин
Директор: М.В. Фалалеев

## 2. Список компетенций

**Дисциплина: Б1.В.ДВ.3.1. Технологии программирования**

- способность приобретать новые научные и профессиональные знания, используя современные образовательные и информационные технологии (ОПК-2)
- способность критически переосмысливать накопленный опыт, изменять при необходимости вид и характер своей профессиональной деятельности (ПК-3)
- способность к разработке и применению алгоритмических и программных решений в области системного и прикладного программного обеспечения (ПК-7)

## 3. Список курсов специальности

- Б1.Б.3 «Философия»

# Imported time distribution for lecture, seminary, ...

загрузке;

- методиками экстремального и *agile*-программирования.

**4. Объем дисциплины (модуля) и виды учебной работы (разделяется по формам обучения)**

| Вид учебной работы | Всего часов / зачетных единиц | Семестры | |
|---|---|---|---|
| | | 3 | 4 |
| **Аудиторные занятия (всего)** | **108** | **33** | **75** |
| в том числе: | | | |
| Лекции | 36 | | 36 |
| Практические занятия (ПЗ) | | | |
| Семинары (С) | | | |
| Лабораторные работы (ЛР) | 66 | 30 | 36 |
| КСР | 6 | 3 | 3 |
| **Самостоятельная работа (всего)** | **45** | **39** | **6** |
| в том числе: | | | |

# Representation of document parts with RDFa

```
<html lang="ru" xmlns=http://www.w3.org/1999/xhtml
 xmlns:taa =http://irnok.net/engine/rdfa-manipulation
xml:lang="ru" metal:define-macro="page">
<head> . . . . </head>
<body prefix="rdf: http://www.w3.org/1999/...-ns# foaf: http://xmlns.com/foaf/...
imei: imei.html# course: https://irnok.net/college/plan/01..16-...\
%D0\%BA_PB-SM.plm.xml.xlsx-....2.3.1.html#"  resource="#post"
typeof="schema:CreativeWork sioc:Post prov:Entity">
<!– The application control panel –>

<main lang="ru" resource="#annotation" typeof="oa:Annotation" id="main-doc-cnt">
<div property="oa:hasTarget" resource="#course-work-prog"></div>
<article property="oa:hasBody" typeof="foaf:Document curr:WorkingProgram"
         resource="#course-work-program" id="main-document">
  <div  taa:content ="imei:title-page"></div>
  <div  taa:content ="imei:neg-UMK"></div>
  <section id="TOC" class="break-after"> <h2>Table of Contents</h2>
    <div id="tableOfContents"></div>
  </section>
  <section id="course-description" resource="#description"
           property="schema:hasPart" typeof="schema:CreativeWork">
    <div property="schema:hasPart" resource="#purpose"
         typeof="dc:Text cnt:ContentAsText" >
      <div property="cnt:chars" datatype="xsd:string">
        <h2 property="dc:title" datatype="xsd:string">
           Aims and objectives of the discipline (module)</h2>
        <p>The aim of teaching the discipline ...</p>
      </div>
   </div>
  . . . . . .
```

# Complete document

**МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ**
**федеральное государственное бюджетное образовательное учреждение высшего образования**
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**Институт математики экономики и информатики**

**Кафедра информационных технологий**

УТВЕРЖДАЮ
_____
Директор ИМЭИ

"___" _____ 20___ г.

**Рабочая программа дисциплины (модуля)**
**Б1.В.ДВ.3.1. Технологии программирования**

| | |
|---|---|
| Направление подготовки: | **10.03.01 (090900) Информационная безопасность** |
| Направленность (профиль) | **- общий** |
| Квалификация (степень) выпускника | **- бакалавр** |
| Форма обучения | **- очная** |

**Иркутск 2016 г.**

Согласовано с УМК факультета (института) _____

Протокол № ___ от "___" _____ 20___ г.

Председатель _____ (подпись)

Рекомендовано кафедрой: _____

Протокол № ___ от "___" _____ 20___ г.

Зав. кафедрой _____ (Ф.И.О.)

**Содержание**



**1. Цели и задачи дисциплины (модуля)**

Целью преподавания дисциплины «Технологии программирования» является освоение студентами практических навыков в области разработки программного обеспечения на основе современных подходов к проектированию сложных, гетерогенных, распределенных информационных систем. Развитие навыков системного мышления, необходимого для

# Discussion

A tools (components) for digital archive implementation, which allows to device information systems and document processing services with the following features:

- load LOD marked up document, extract, store in a graph and index RDF data;
- retrieve RDF data as triples or as a result of full-text search query;
- combine existing LOD data and its content in new documents dynamically with browser based context inference machine;
- use server-site inference machine (Prolog) to process RDF data upon request from browser's part of the system;
- convert created RDFa marked up HTML5 documents into Excel and Word formats.

**Applications**

- Document authoring automation;
- Context-depended editing;
- Self-organizing global document flows;
- Documents as data sources for information systems.

# Cartographical WEB-service with knowledge graph of South-Siberian faults

**Aim** is to construct a WEB-GIS browser for faults stored in the KG.

- Scalability to external data with converters (TODO)
- Interdisciplinary data representation
- Application development with nowadays WEB techniques
- Digital platform for data publication in “Digital Baikal” project

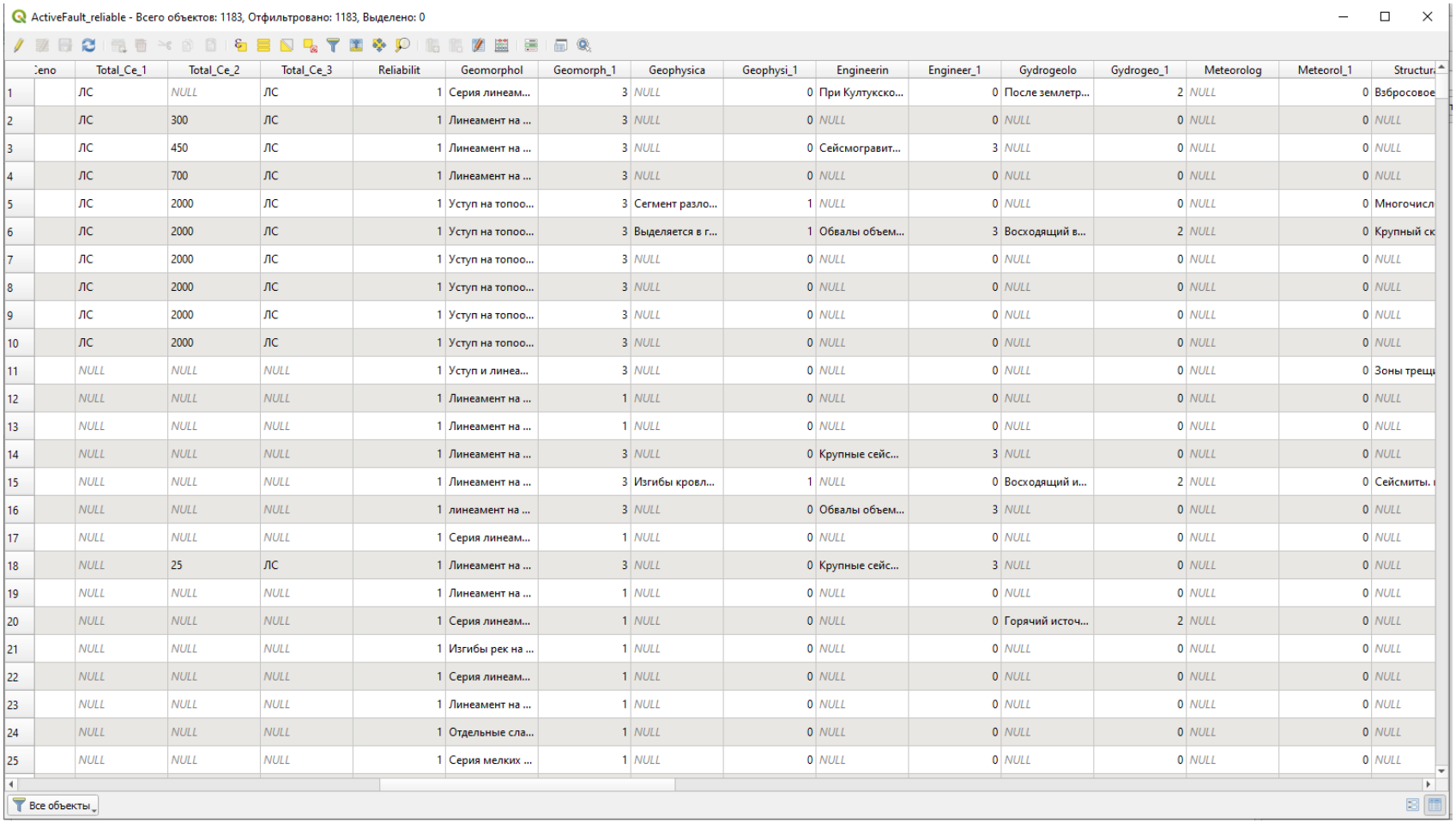
Development **plan**

- Investigate the current data formats
- Develop T-Box
- Fill in A-Box
- Expose the KG with a server
- Implement browsing SPARQL query results with GIS
- Develop object browser

MVP is a WEB-GIS with the most of the listed features.

# GIS source data table properties

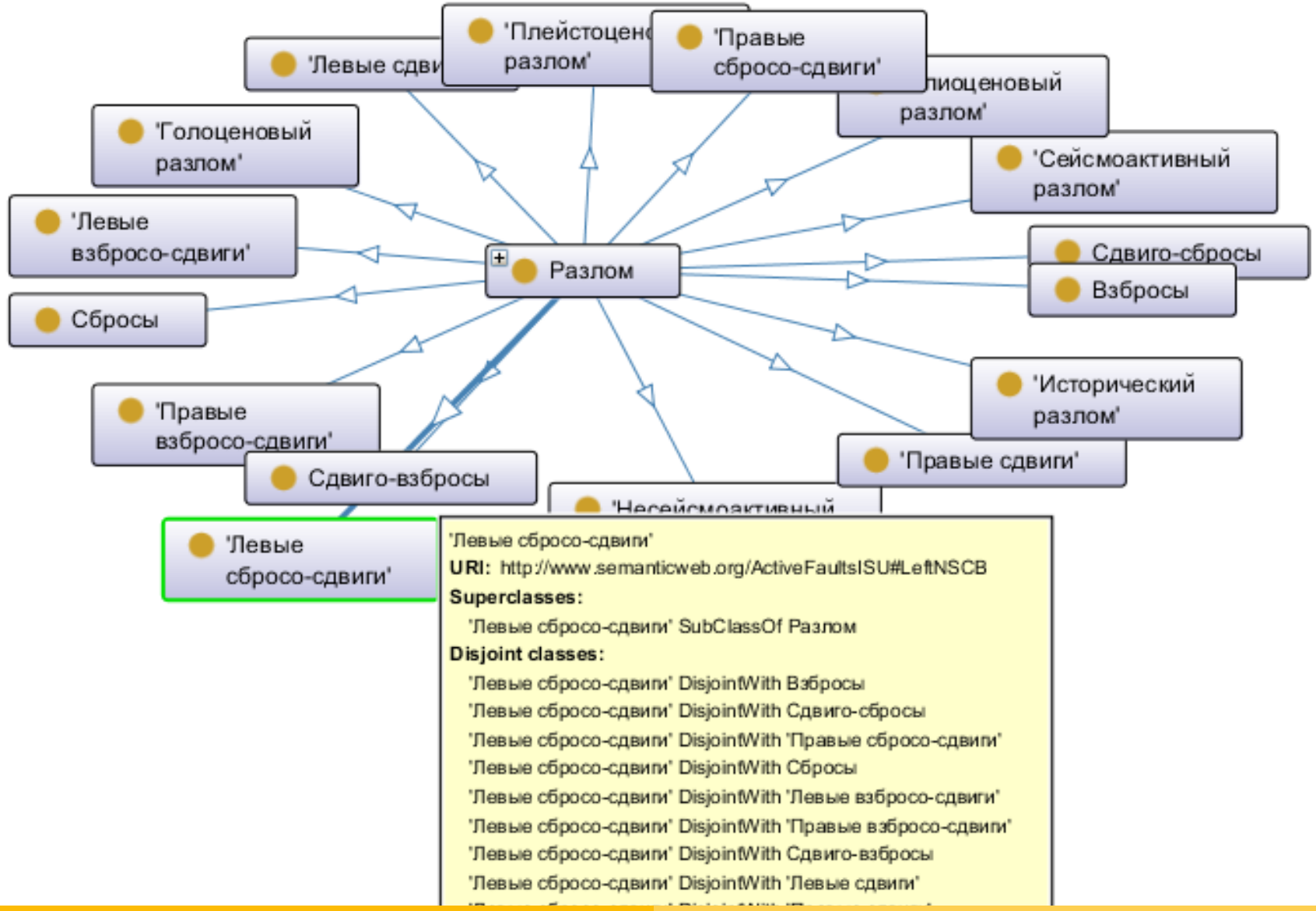
- Only one table, one row for each GIS object
- There are many NULL values
- More than 1000 objects
- More than 70 attributes (according to O.V. Lunina, PhD)




| | ;eno | Total_Ce_1 | Total_Ce_2 | Total_Ce_3 | Reliabilit | Geomorphol | Geomorph_1 | Geophysica | Geophysi_1 | Engineerin | Engineer_1 | Gydrogeolo | Gydrogeo_1 | Meteorolog | Meteorol_1 | Structur |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | ЛС | NULL | ЛС | 1 | Серия линеам... | 3 | NULL | 0 | При Култукско... | 0 | После землетр... | 2 | NULL | 0 | Взбросовое |
| 2 | | ЛС | 300 | ЛС | 1 | Линеамент на ... | 3 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 3 | | ЛС | 450 | ЛС | 1 | Линеамент на ... | 3 | NULL | 0 | Сейсмогравит... | 3 | NULL | 0 | NULL | 0 | NULL |
| 4 | | ЛС | 700 | ЛС | 1 | Линеамент на ... | 3 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 5 | | ЛС | 2000 | ЛС | 1 | Уступ на топоо... | 3 | Сегмент разло... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | Многочисл |
| 6 | | ЛС | 2000 | ЛС | 1 | Уступ на топоо... | 3 | Выделяется в г... | 1 | Обвалы объем... | 3 | Восходящий в... | 2 | NULL | 0 | Крупный ск |
| 7 | | ЛС | 2000 | ЛС | 1 | Уступ на топоо... | 3 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 8 | | ЛС | 2000 | ЛС | 1 | Уступ на топоо... | 3 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 9 | | ЛС | 2000 | ЛС | 1 | Уступ на топоо... | 3 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 10 | | ЛС | 2000 | ЛС | 1 | Уступ на топоо... | 3 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 11 | | NULL | NULL | NULL | 1 | Уступ и линеа... | 3 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | Зоны трещ |
| 12 | | NULL | NULL | NULL | 1 | Линеамент на ... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 13 | | NULL | NULL | NULL | 1 | Линеамент на ... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 14 | | NULL | NULL | NULL | 1 | Линеамент на ... | 3 | NULL | 0 | Крупные сейс... | 3 | NULL | 0 | NULL | 0 | NULL |
| 15 | | NULL | NULL | NULL | 1 | Линеамент на ... | 3 | Изгибы кровл... | 1 | NULL | 0 | Восходящий и... | 2 | NULL | 0 | Сейсмиты. |
| 16 | | NULL | NULL | NULL | 1 | линеамент на ... | 3 | NULL | 0 | Обвалы объем... | 3 | NULL | 0 | NULL | 0 | NULL |
| 17 | | NULL | NULL | NULL | 1 | Серия линеам... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 18 | | NULL | 25 | ЛС | 1 | Линеамент на ... | 3 | NULL | 0 | Крупные сейс... | 3 | NULL | 0 | NULL | 0 | NULL |
| 19 | | NULL | NULL | NULL | 1 | Линеамент на ... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 20 | | NULL | NULL | NULL | 1 | Серия линеам... | 1 | NULL | 0 | NULL | 0 | Горячий источ... | 2 | NULL | 0 | NULL |
| 21 | | NULL | NULL | NULL | 1 | Изгибы рек на ... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 22 | | NULL | NULL | NULL | 1 | Серия линеам... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 23 | | NULL | NULL | NULL | 1 | Линеамент на ... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 24 | | NULL | NULL | NULL | 1 | Отдельные сла... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |
| 25 | | NULL | NULL | NULL | 1 | Серия мелких ... | 1 | NULL | 0 | NULL | 0 | NULL | 0 | NULL | 0 | NULL |

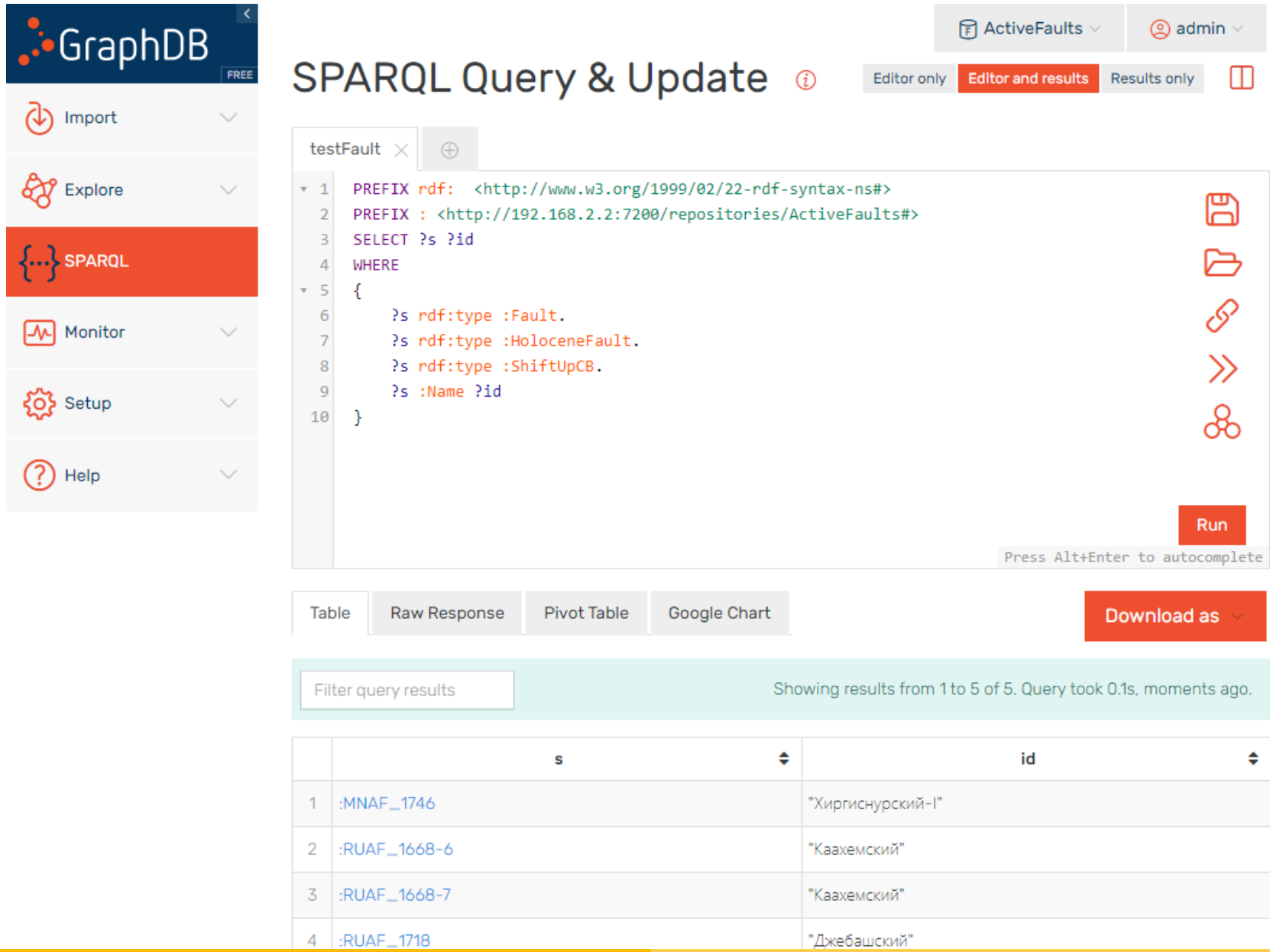
# Developed ontology

The ontology contains nonintersection properties for its classes

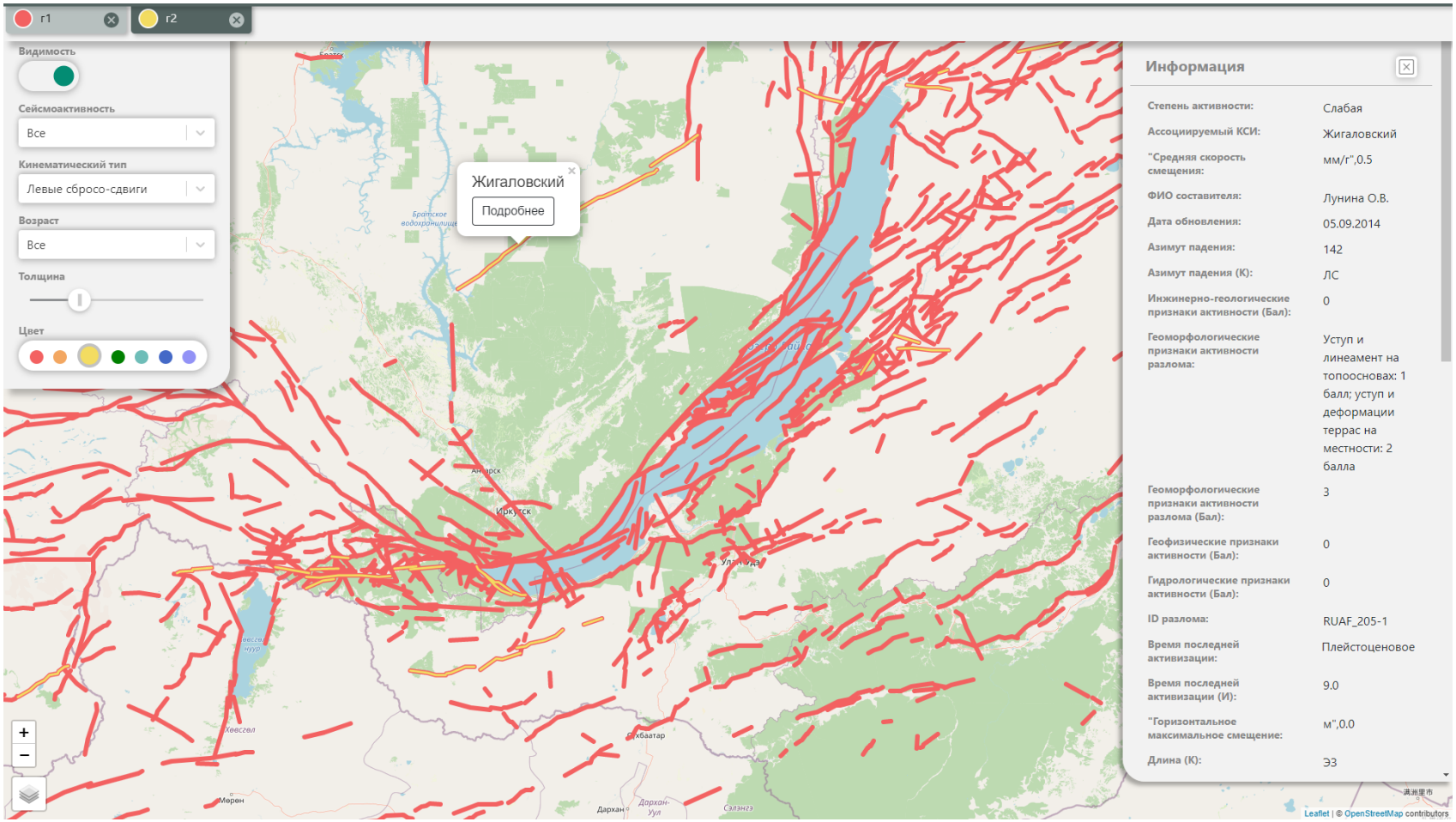


# Serving ontology and its A-box

As server GraphDB is used.



# Web GIS


r1
r2
Видимость
Сейсмоактивность
Все
Кинематический тип
Левые сбросо-сдвиги
Возраст
Все
Толщина
Цвет
Жигаловский
Подробнее
Информация
Степень активности: Слабая
Ассоциируемый КСИ: Жигаловский
"Средняя скорость смещения: мм/г",0.5
ФИО составителя: Лунина О.В.
Дата обновления: 05.09.2014
Азимут падения: 142
Азимут падения (К): ЛС
Инжинерно-геологические признаки активности (Бал): 0
Геоморфологические признаки активности разлома: Уступ и линеамент на топоосновах: 1 балл; уступ и деформации террас на местности: 2 балла
Геоморфологические признаки активности разлома (Бал): 3
Геофизические признаки активности (Бал): 0
Гидрологические признаки активности (Бал): 0
ID разлома: RUAF_205-1
Время последней активизации: Плейстоценовое
Время последней активизации (И): 9.0
"Горизонтальное максимальное смещение: м",0.0
Длина (К): ЭЗ
Братское водохранилище
Иркутск
Мөрөн
Дархан
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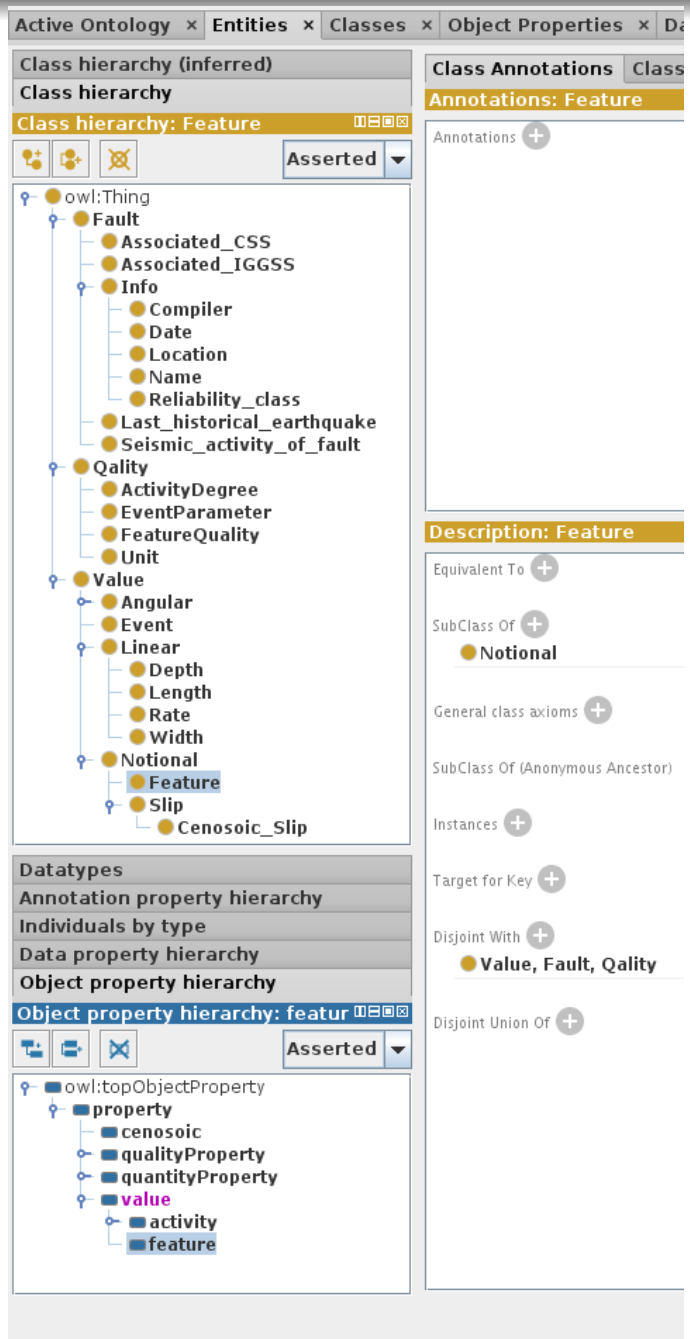
# Used technologies for constructing WEB-GIS browser




# Ontological instruments: editor Protegé

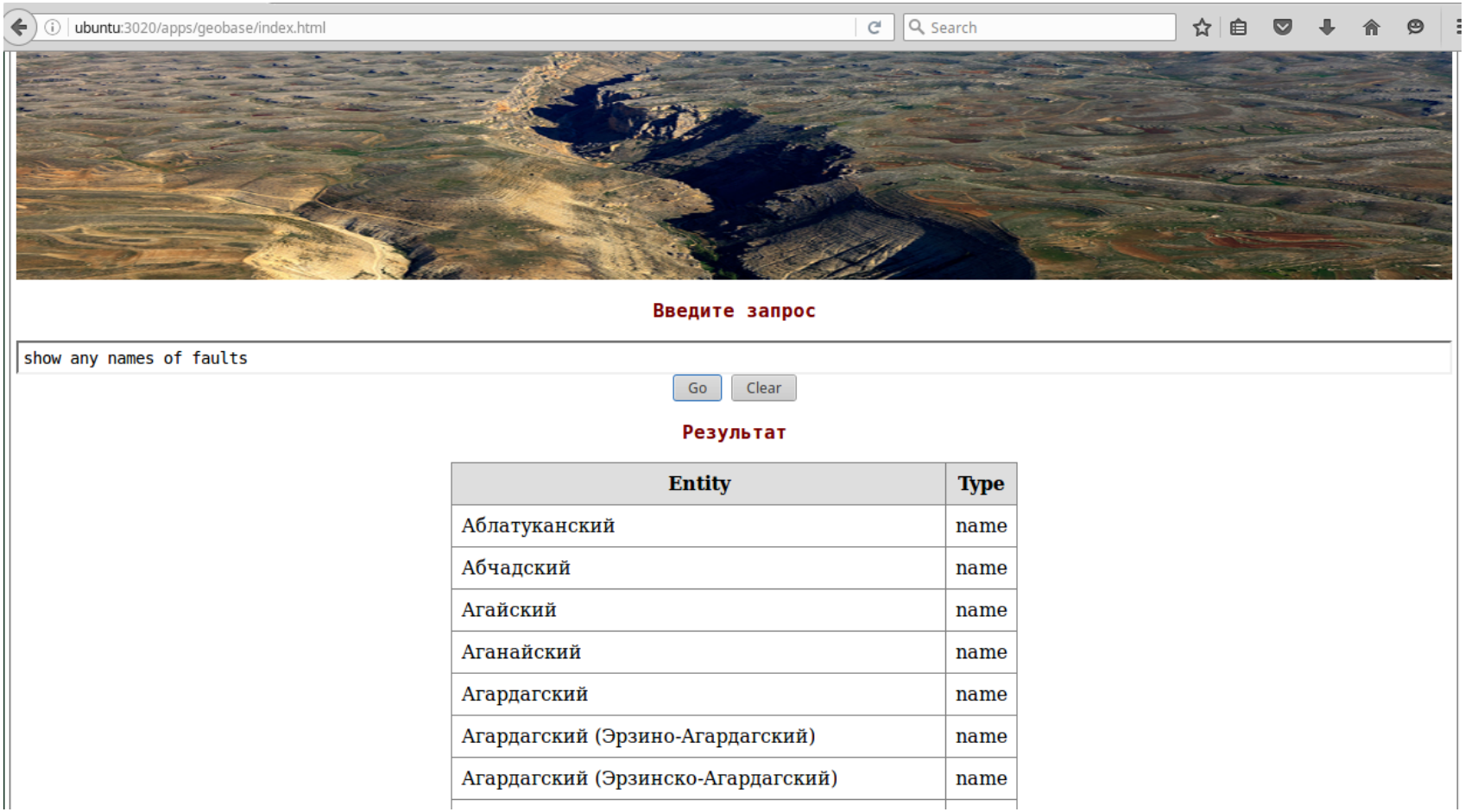



```
[eugeneai@center data]$ head -n 50 activity_fall_data.ttl
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix geob: <http://www.semanticweb.org/bernard_black/ontologies/2016/3/
@prefix nie: <http://www.semanticdesktop.org/ontologies/2007/01/19/nie#> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

[] a geob:Fault ;
    nie:identifier "RUAF_235-1" ;
    nie:title "Северобайкальский" ;
    geob:activity [ a geob:Activity ;
            geob:degree "повышенная" ;
            geob:eventage [ a geob:EventAge ;
                    geob:index 2e+00 ;
                    geob:type geob:LastActivationAge ;
                    geob:value "Голоценовое" ] ;
            geob:value 1.4e+01 ] ;
    geob:angle [ a geob:Angle ;
            geob:quality "ЛС" ;
            geob:value "50-80" ] ;
    geob:azimuth [ a geob:Azimuth ;
            geob:quality "ЛС" ;
            geob:value 1.02e+02 ] ;
    geob:cenosoicslip [ a geob:CenosoicSlip ;
            geob:quality "ЛС" ;
            geob:reliabilityClass 1e+00 ;
            geob:type geob:vertical ;
            geob:value 4e+03 ] ;
    geob:compiler [ a geob:Compiler ;
            nie:created "15.11.2014" ;
            foaf:name "Лунина О.В." ] ;
    geob:event [ a geob:Event ;
            geob:associatedCSS "Северобайкальский" ;
            geob:averaged_slip_rate_mm_year 3e+00 ;
            geob:isActiveFault "Да" ;
            geob:potential_ms_max 7.7e+00 ;
            geob:potential_mw_max 0e+00 ;
            geob:quality "ЛС" ;
            geob:slip_rate_mm_year "1-4.99" ;
            geob:type geob:TotalMaxSlip ;
            geob:value 9e+00 ],
        [ a geob:Event ;
            geob:type geob:LateralMaxSlip ;
            geob:value 0e+00 ],
        [ a geob:Event ;
            geob:type geob:VerticalMaxSlip ;
            geob:value 9e+00 ] ;
    geob:feature [ a geob:Feature ;
[eugeneai@center data]$
```

# Modification of GeoBase supporting Semantic WEB

```
schema('fault','in','continent').  % Connect our relations with GeoBase
schema('fault','with','feature').  % vocabulary.
schema('name','of','fault').       %
% schema('feature','of','fault').  % This relation is already in the T-Box''

% «Загрузка» онтологий
schema(Prop, 'of', SubjName):-     % used on translation stage
        var(SubjName),
        geob_prop(Prop,_).

schema(Prop, 'of', SubjName):-     % used on stage of interpretation
        nonvar(SubjName),          % a Class is supplied
        geob_prop(Prop, GProp),
        geob_ent_class(SubjName, Subj),
        rdf_reachable(Subj, rdfs:subClassOf, Parent),
        rdf(GProp, rdfs:domain, Parent),!.

geob_prop(Prop, GProp):-           % Property check
        rdf_global_id(geob:Prop, GProp),
        rdf(GProp,rdf:type,owl:'ObjectProperty'),!.

geob_class(Class, GClass):-        % Class check
        rdf_global_id(geob:Class, GClass),
        rdf(GClass,rdf:type,owl:'Class'),!.
```

# GeoBase to ActiveFaults Natural language interface




**New problem** for student graduation project: Implement Natural Language to SPARQL translator.

# Conclusion

The following results have been obtained as for today:

- A technique for **domain** model representation has been developed and tested.
- A programming technique using object-oriented logical language Logtalk is devised.
- Prototypes of various transformation procedures are implemented.
- Transformation tools are tested in application areas and no significant technical problems were mentioned.

Further development directions are as follows:

- A technique for document automatic markup with vocabulary entities.
- A transformation implemenation techniques, minimizing usage of dynamic objects, targeting on macro properties of Logtalk.
- Form a toolset out of existing prototypes obeying nowadays software development requirements.

The source codes are available at
https://github.com/isu-enterprise/icc.xmitransform,
https://github.com/eugeneai/icc.mothurpim.

# Technologies used (open source)

Python-3.x.x (http://python.org),
ZCA (https://muthukadan.net/docs/zca.html),
SWIG (http://swig.org/),
SWI-Prolog (https://www.swi-prolog.org/),
Logtalk (https://logtalk.org/),
ClioPatria (https://cliopatria.swi-prolog.org/home),
Pengines (https://pengines.swi-prolog.org/docs/index.html),
LOV (https://lov.linkeddata.es/dataset/lov/),
Elastic Search (https://www.elastic.co/),
Kyotocabinet (https://fallabs.com/kyotocabinet/),
DBPedia (https://wiki.dbpedia.org/),
Mothur (https://mothur.org/),
Galaxy (https://usegalaxy.org/),
R (https://www.r-project.org/),
Dust.js (https://akdubya.github.io/dustjs/)

Thanks for Your Attention!