Information infrastructure for supporting Baikal microbiome research

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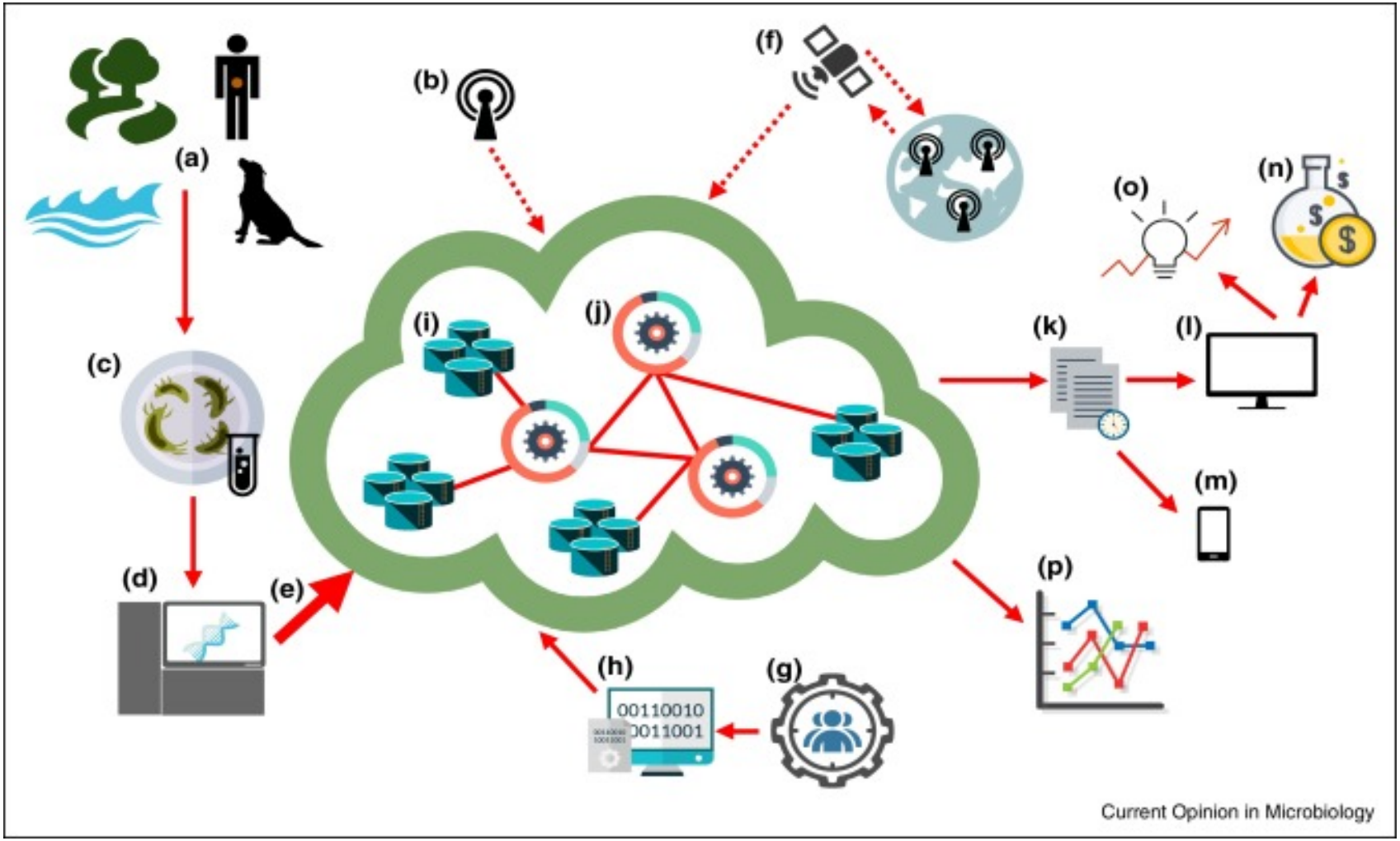
Microbiome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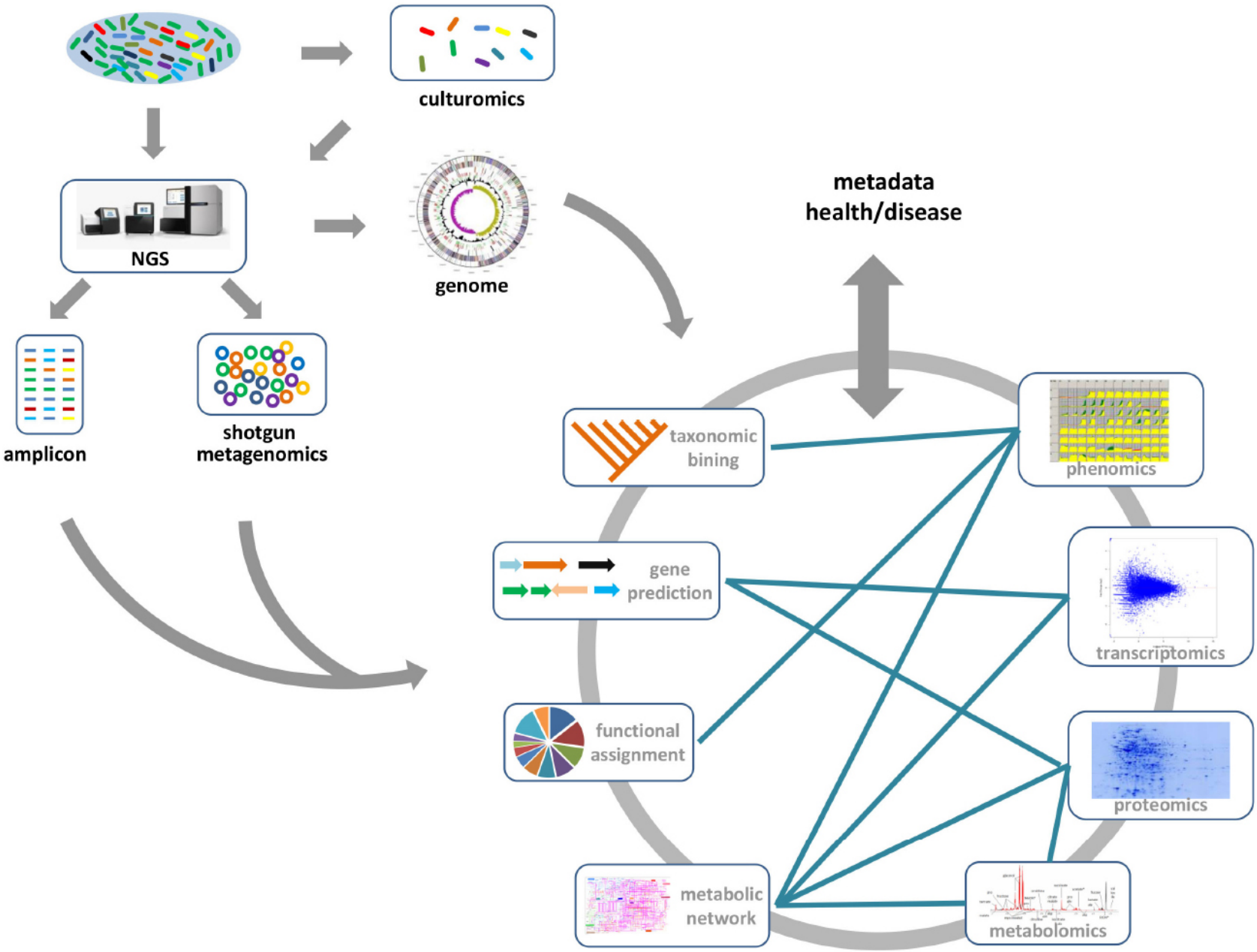
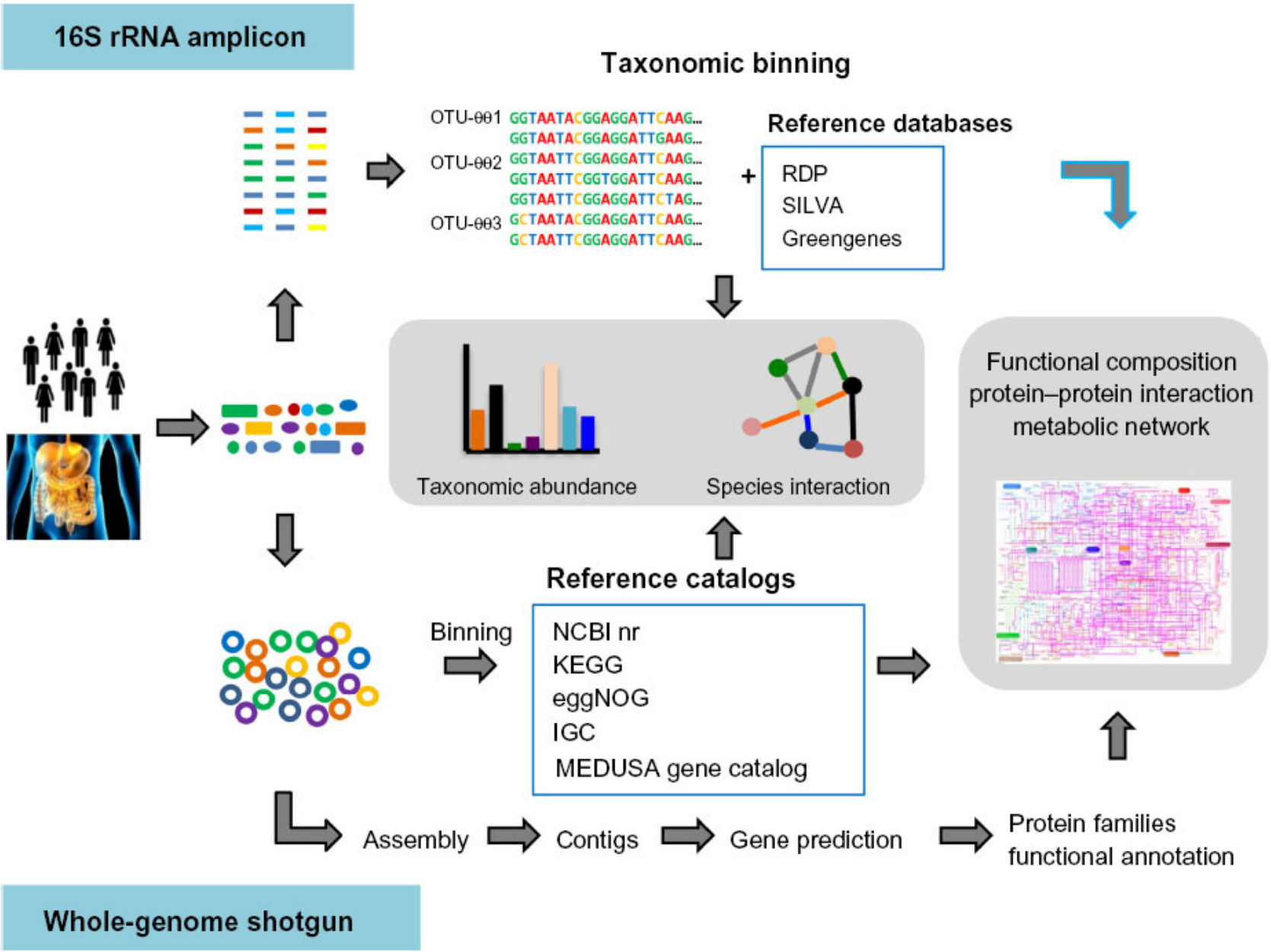
Current Opinion in Microbiology

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

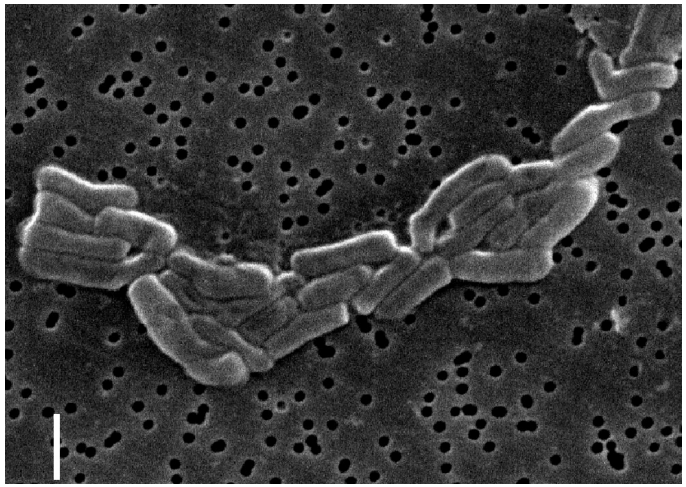
Alignment (an example)

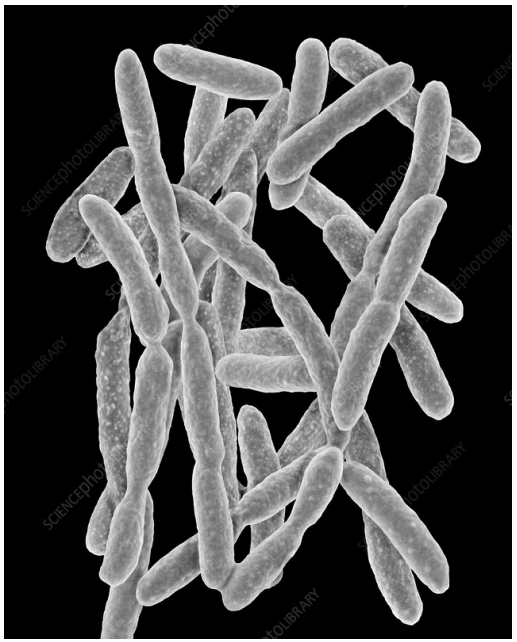
```
align.seqs(fasta=HXH779K01.shhh.trim.good.unique.fasta, reference=silva.bacteria.fasta)

HXH779K01.shhh.trim.good.unique.align
HXH779K01.shhh.trim.good.unique.align.report
HXH779K01.shhh.trim.good.unique.flip.accnos

summary.seqs(fasta=HXH779K01.shhh.trim.good.unique.align,
      count=HXH779K01.shhh.trim.good.count_table)

Start End NBases Ambigs Polymer NumSeqs
Minimum: 6237 22529 5 0 1 1
2.5%-tile: 6428 22577 409 0 4 835
25%-tile: 6428 25292 420 0 4 8349
Median:  6428 25292 423 0 5 16697
75%-tile: 6428 25292 442 0 5 25045
97.5%-tile: 6430 25293 446 0 6 32558
Maximum: 43107 43116 476 0 9 33392
Mean: 6435 25061 429 0 4
# of unique seqs: 26744
total # of seqs: 33392

It took 21 secs to summarize 33392 sequences.
```

OTU classification analysis (an example)

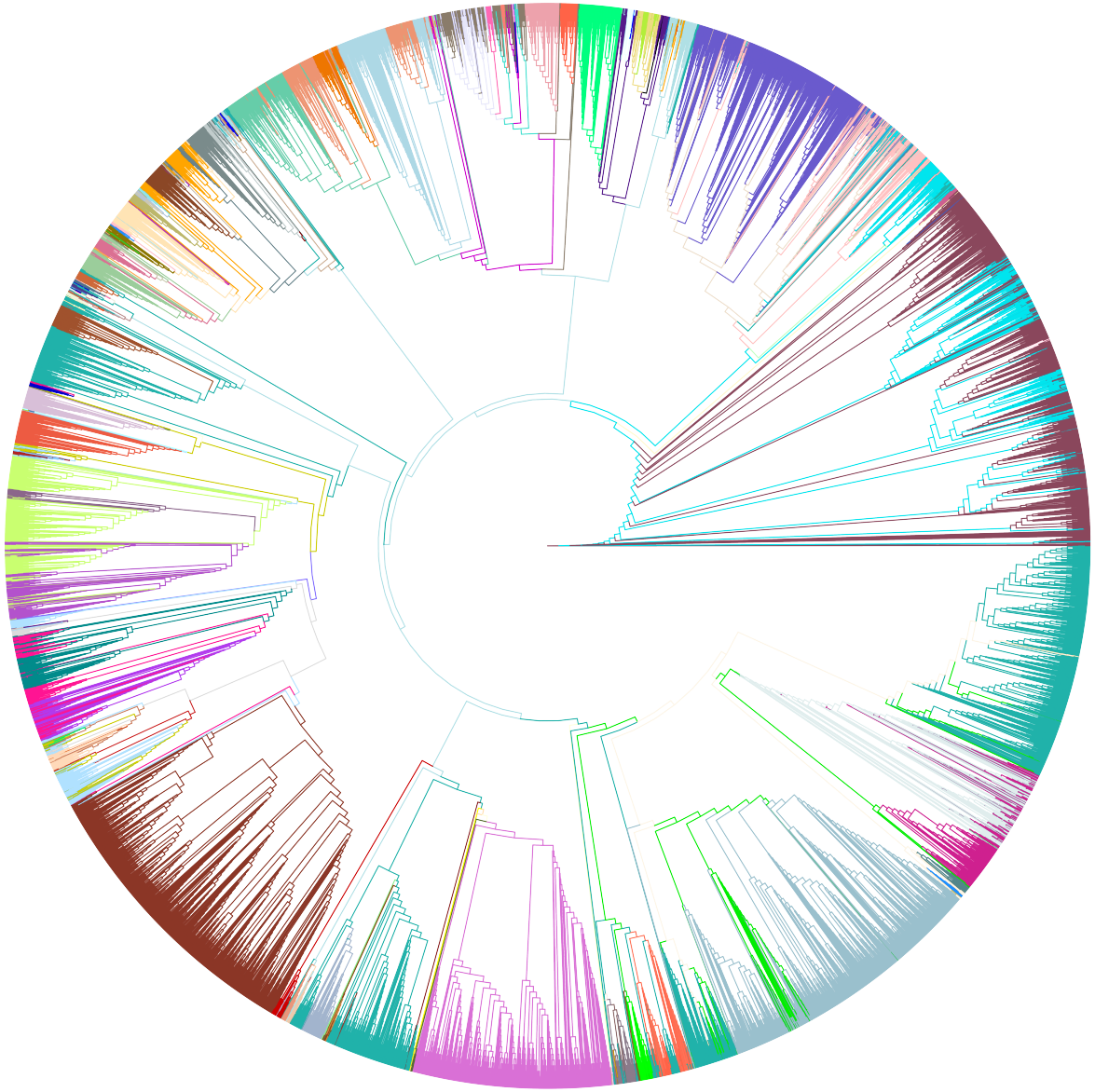
```
classify.otu(list=HXH779K01.shhh.trim.good.unique.good.filter.unique.precluster.pick.pick.opti_mcc.list,
 count=HXH779K01.shhh.trim.good.unique.good.filter.unique.precluster.denovo.vsearch.pick.pick.count_table,
 taxonomy=HXH779K01.shhh.trim.good.unique.good.filter.unique.precluster.pick.rdp.wang.pick.taxonomy,
 label=0.03)
```

```
OTU     Size    Taxonomy
Otu001  2883    Bacteria(100);Bacteria_unclassified(100);Bacteria_unclassified(100);
                Bacteria_unclassified(100);Bacteria_unclassified(100);Bacteria_unclassified(100);
Otu003  1038    Bacteria(100);"Actinobacteria"(100);Actinobacteria(100);Actinomycetales(100);
                Actinomycetales_unclassified(100);Actinomycetales_unclassified(100);
Otu005  660     Bacteria(100);"Actinobacteria"(100);Actinobacteria(100);Acidimicrobiales(100);
                Acidimicrobiaceae(99);Ilumatobacter(99);
Otu007  497     Bacteria(100);"Verrucomicrobia"(100);Subdivision3(100);Subdivision3_..._sedis(100);
                Subdivision3_..._unclassified(100);Subdivision3_genera_incertae_sedis_unclassified(100);
Otu008  484     Bacteria(100);"Bacteroidetes"(100);Flavobacteria(100);"Flavobacteriales"(100);
                Flavobacteriaceae(100);Flavobacterium(100);
```



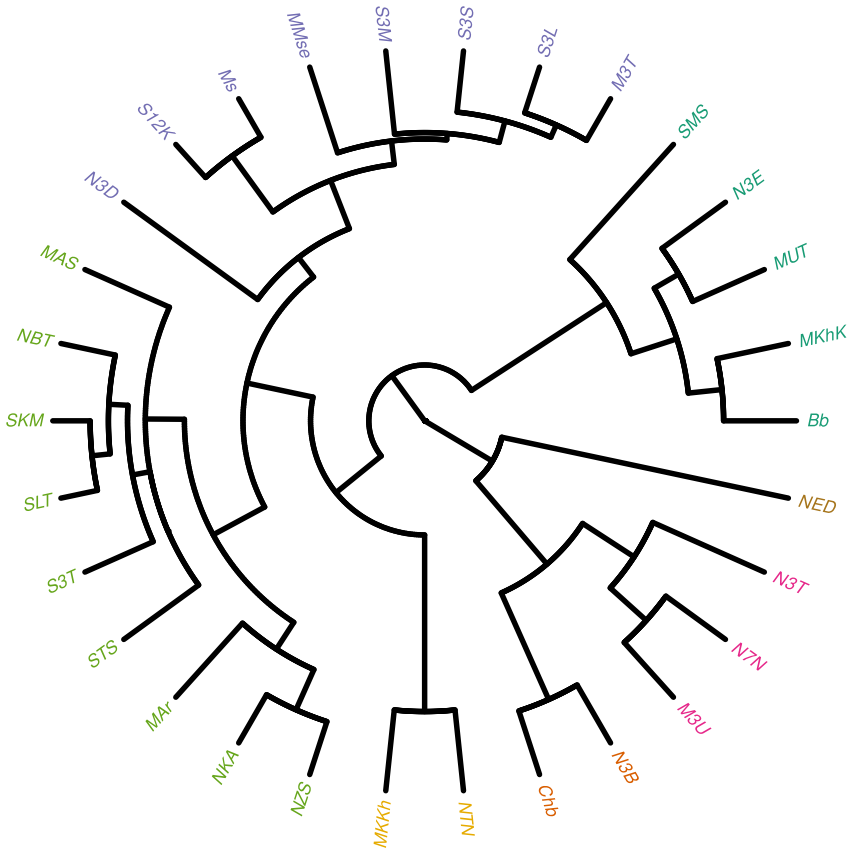


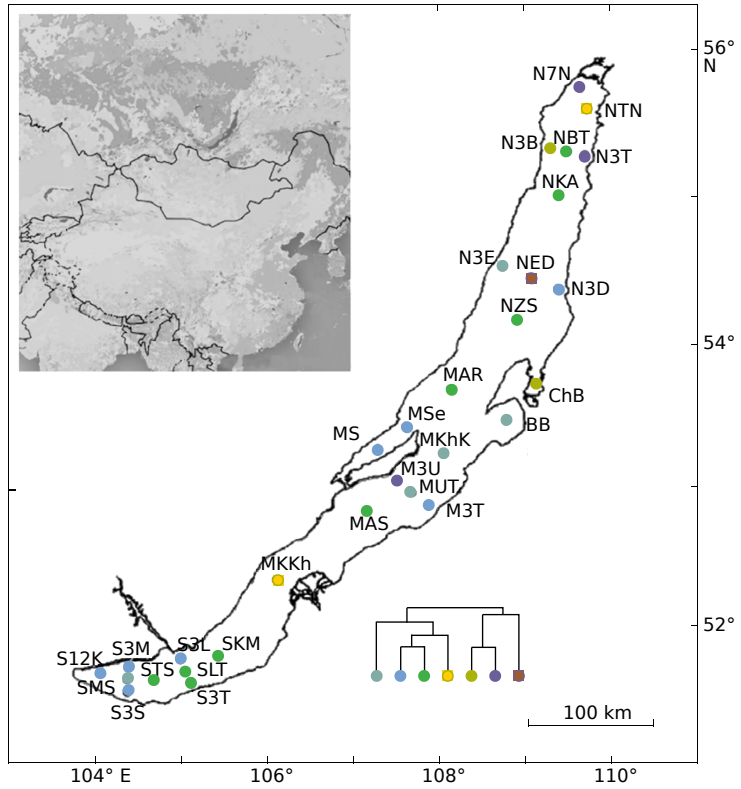
Phylogenetic OTU investigations



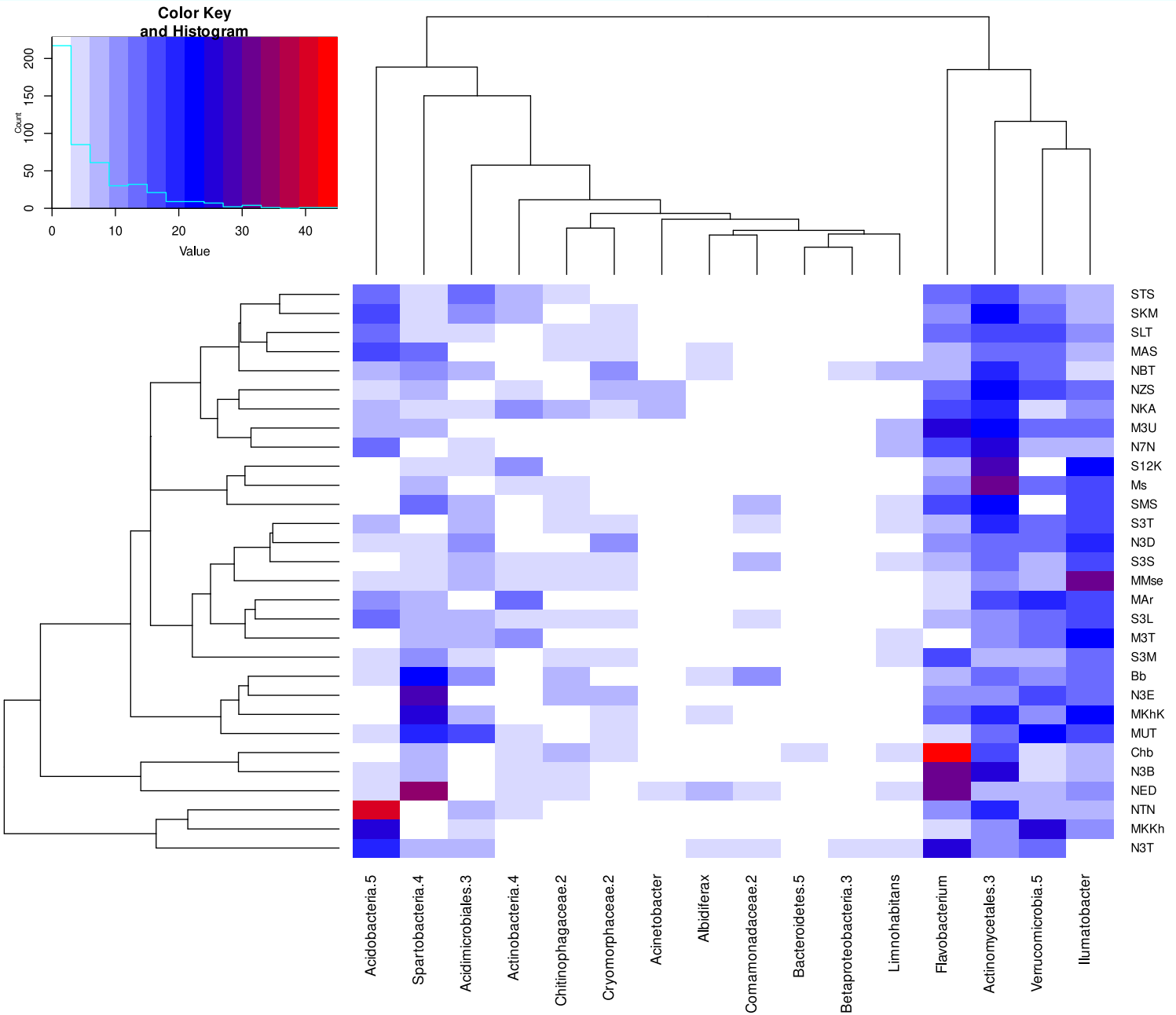
A “taxonomy” of groups

The taxonomy is build using unique sequences as a comparison basis.

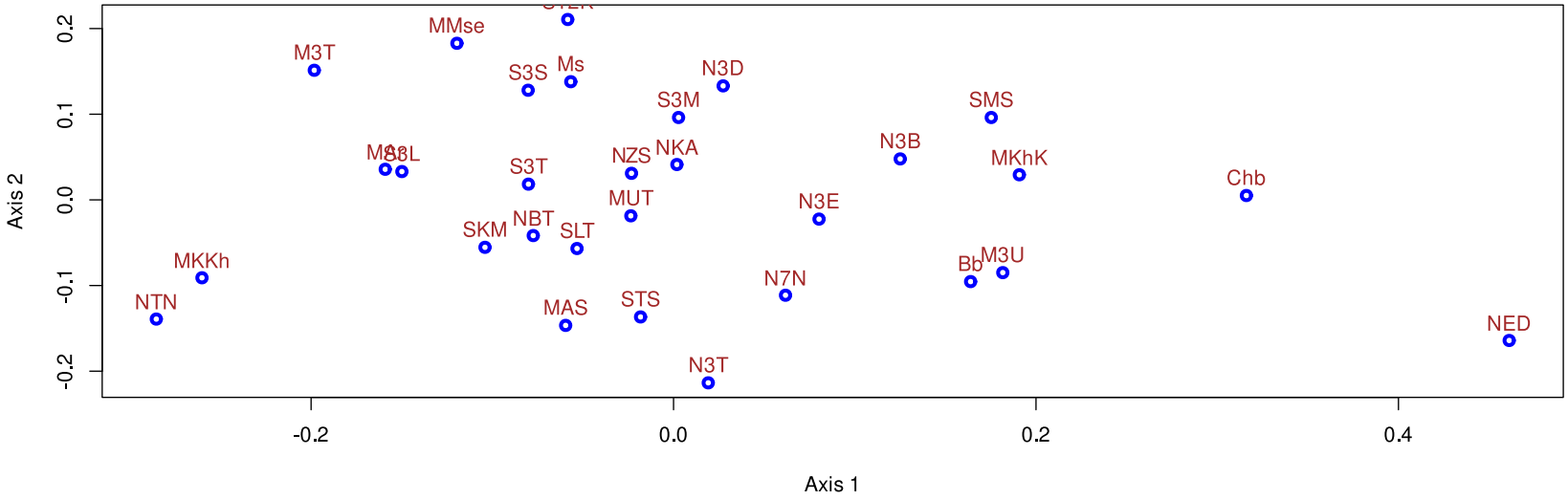




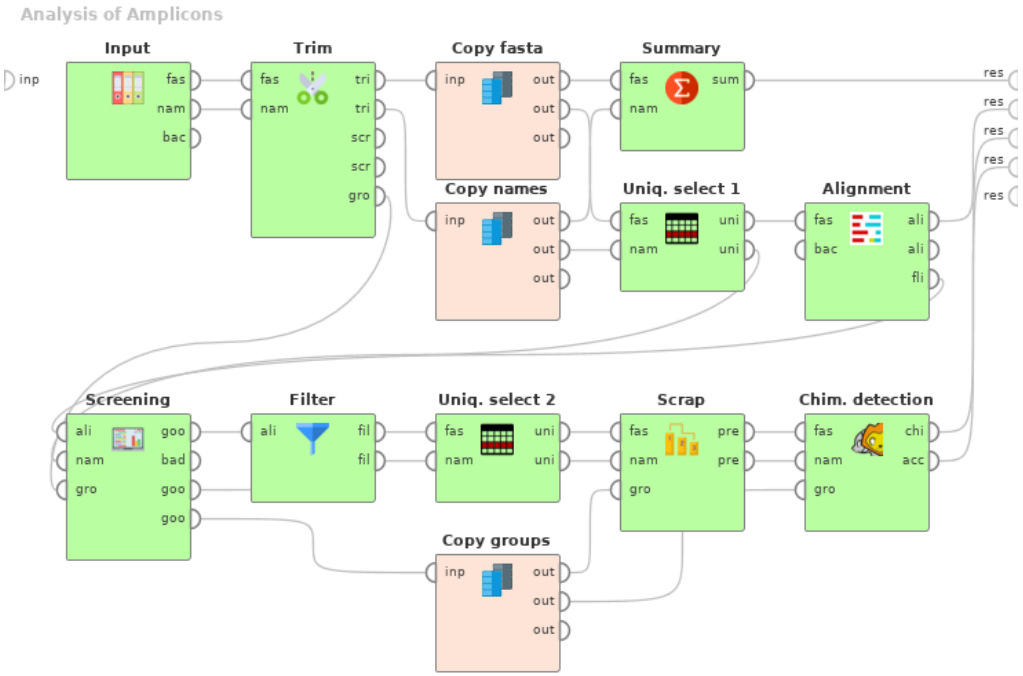
Alpha-diversity



Beta-diversity



Dataflow representation of NGS analysis of amplicons



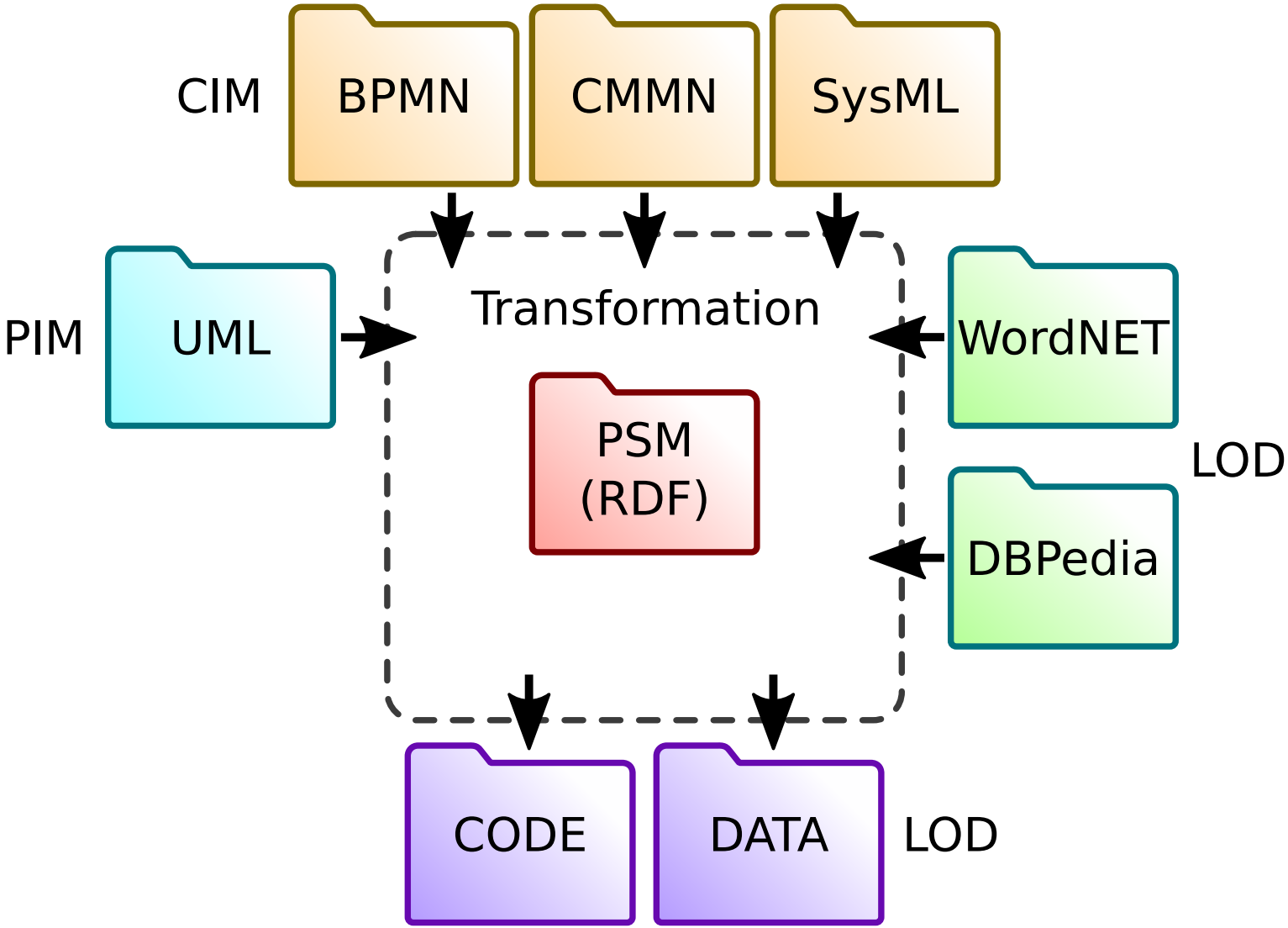
Term	Description
NGS	New Generation Sequencing
Amplicon	A DNA or RNA part copied many times
Mothur	A software toolset for NGS research
Rapidminer	A visual tool for data mining modeling and execution

Green blocks are Mothur modules.
Others are Rapidminer modules.

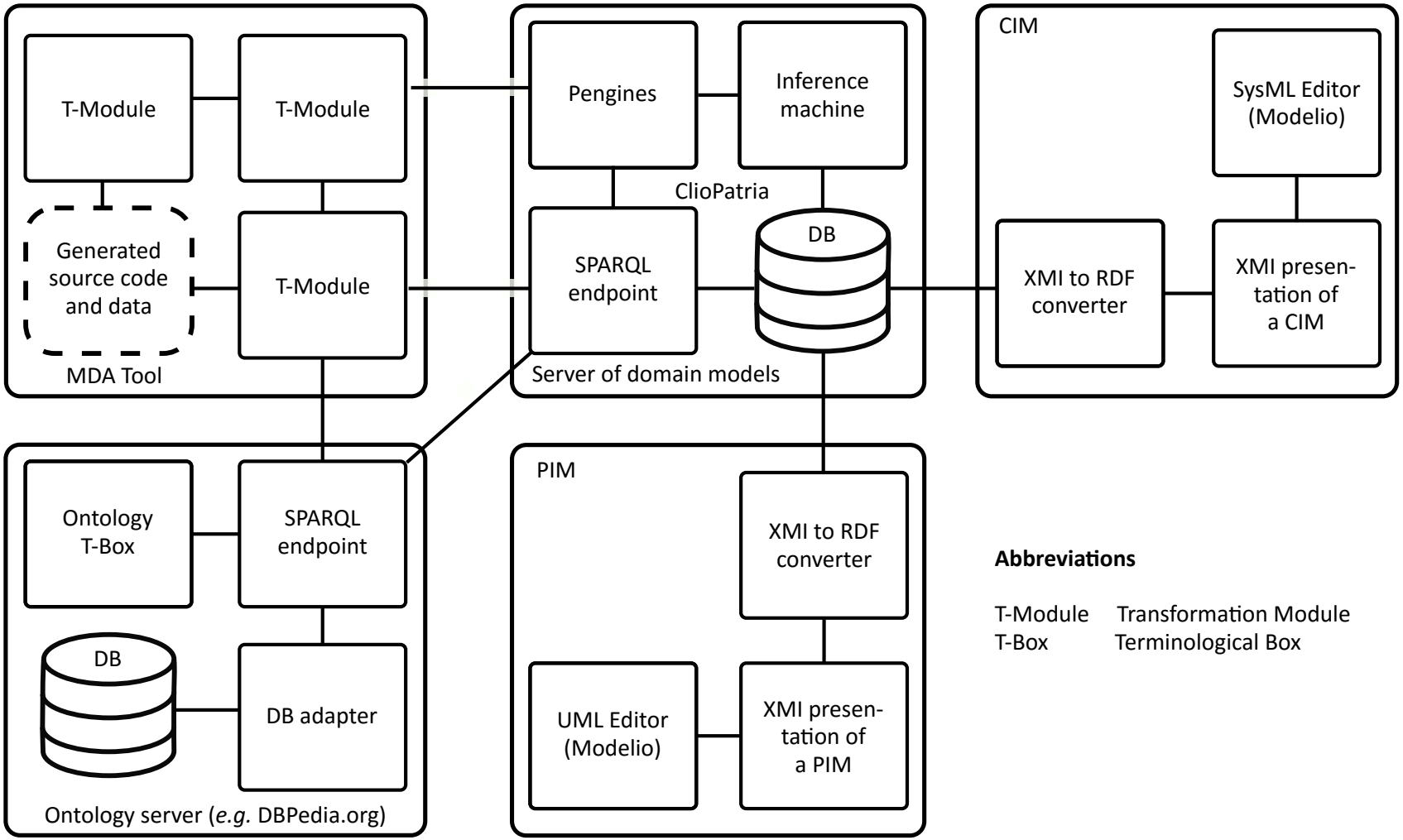
Rapidminer module

```
vector<string> AlignCommand::setParameters(){ // PART OF MODULE SOURCE
try {
  CommandParameter ptemplate("reference", "InputTypes", "", "", "none", "none", "none","",false,true,true); parameters.push_back(
  CommandParameter pcandidate("fasta", "InputTypes", "", "", "none", "none", "none","fasta-alignreport-accnos",false,true,true);
  CommandParameter psearch("search", "Multiple", "kmer-blast-suffix", "kmer", "", "", "","",false,false,true); parameters.push_ba
  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 List<ParameterType> getParameterTypes() {
    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);
  }
}
```

Model Driven Architecture and Linked Open Data



MDA infrastructure



Abbreviations

T-Module	Transformation Module
T-Box	Terminological Box

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.

Semantic Web technologies in representation of models during transformation

- Assimilates experience of domain basic researches trending to standardization;
- Regular set of triples denote a graph (T-Box, A-Box);
- Standard vocabularies are formally described (`rdfs:domain`, `rdfs:range`);
- Supported with most programming systems (libraries, inference engines, SPARQL);
- RDF has a way of global element identification, *i.e.* we can refer the same object from different software systems;
- SWI-Prolog supports direct queries to a graph, as well as interpreting some predicates (`rdfs:label`, `dc:title`), wraps sparse RDF structure into a predicate arguments; ontological server ClioPatria;
- There is simple way of data security implementation (`rdfs:seeAlso`);
- By means of Semantic Web & LOD we are able to organize data transfer between heterogeneous information systems.

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 resources 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.

Linked Open Data, LOD

1. Information is published in Internet with open access license;
2. It is represented in a machine-readable form, e.g., Excel table instead of a bitmap picture;
3. An open format used, e.g., CSV instead of Excel;
4. The format is based on W3C recommended standards, allowing RDF and SPARQL reference;
5. Published data refer to objects, forming context.

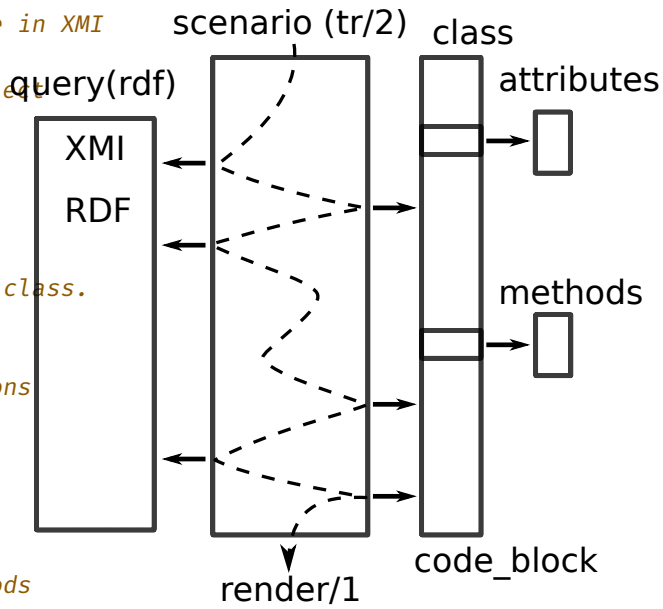
Thus, applications publish data as relations of objects (entities).

RDF (TTL) representation and ad 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 ;
# . . . . .
```

PSM: Scenario of a Class synthesis

```
:- object(direct(_Package,_LocalProf,_CodeProf)).     % Transformation driver object
:- public([tr/4,tr/3]).                               % Public interface of a class synthesis scenario
% . . . . . .
tr(class, Class, ClassID):- ::package(Package),       % Synthesize a class
    query(Package)::class(Name, ClassID),             % Query package structure in XMI
    create_object(Class,      % . . . . .             % Create a «Class» object
    create_object(Attributes, % . . . . .             % Create «Attributes» object
    create_object(Methods,    % . . . . .             % ...«Methods».
    Class::name(Name),                                % Name the class.
    % Generate attributes of the class,
    % organizing them in a local database.
    % ...methods...
    Class::attributes(Attributes),                    % Set the attributes for class.
    Class::methods(Methods).                          % ...methods.

tr(attribute, Attribute, ClassID, AttributeID):-      % Attribute transformations
    ::package(Package),
    query(Package)::attribute(Name,ClassID,AttrID),
    create_object(Attribute,  % . . . . .
    Attribute::name(Name).                            % Name the attribute.

tr(method, Method, ClassID, MethodID):-               % Transformation of methods
    ::package(Package),
    query(Package)::method(Name,ClassID,MethodID),
    create_object(Method,     % . . . . .
    Method::name(Name).                               % Name of the method
:- end_object.
```

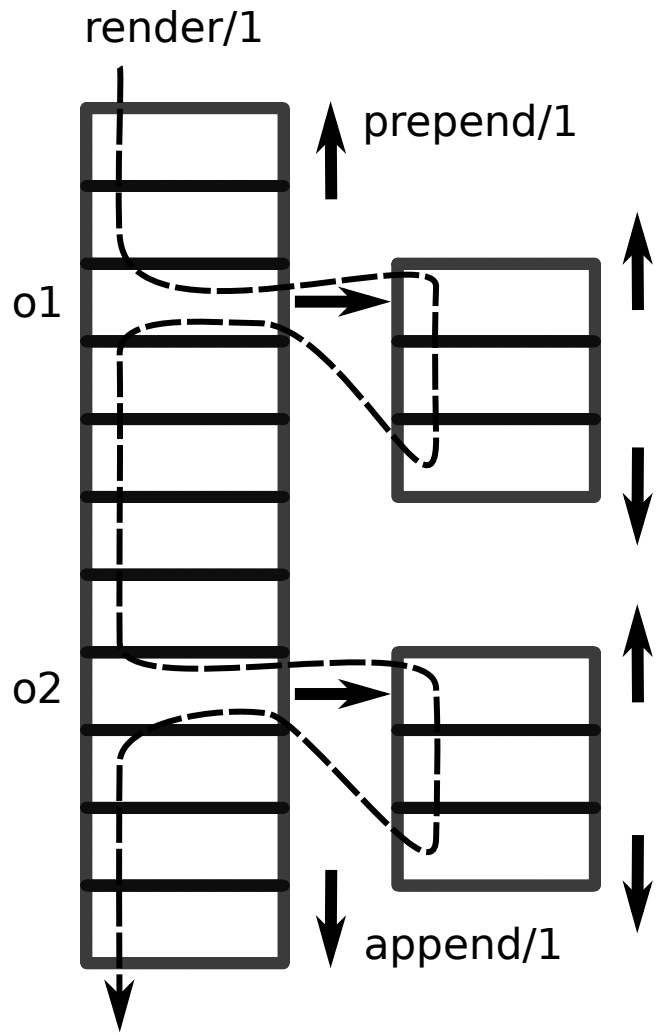


Implementation of Query object

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

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

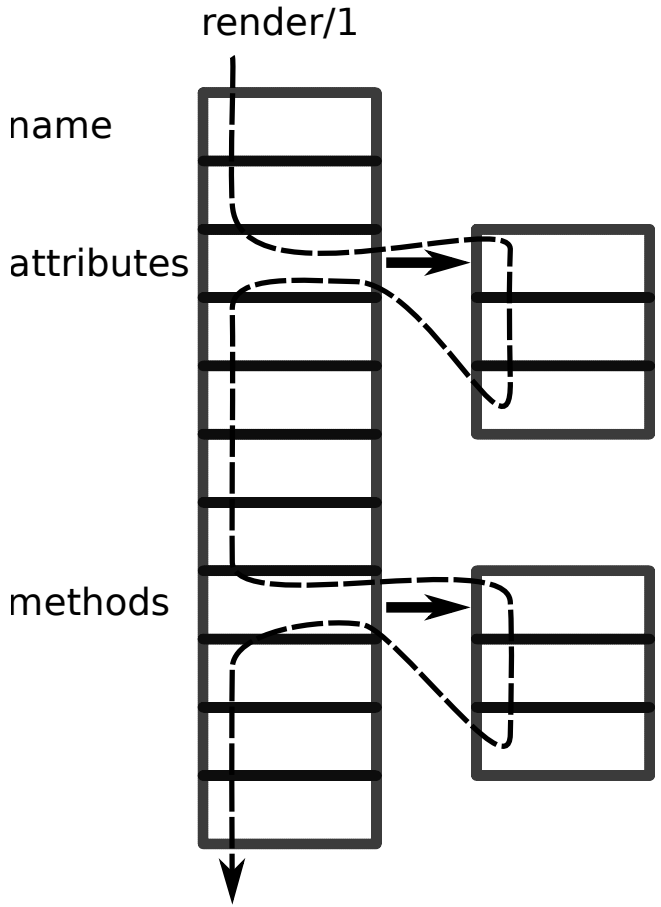
```
:- object(code_block, specializes(root)).
% Public interface of the object
:- public([append/1, prepend/1, clear/0,
   render/1, render_to/1, remove/1,
   item/1, items/1]).
% Code block items
:- dynamic([item_/1]).
:- private([item_/1]).
% Methods specialized during inheritance
:- protected([renderitem/2, 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 the 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. Implement a cloud or cluster computing environment for HPC processing the procedures.
3. 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.
4. Realize adapters of data/metadata storage and retrieving, as well as the storage.
5. Adapt our "pattern-directed" approach of semantically marked up document authoring to present input and output to the scientific communities.
6. Implement integration to biological/gene databases.
7. Write a handbook on Logtalk programming strategies with its author Paulo Mora.

Conclusion

The following results have been obtained as for today:

- A part of biologists' activities was investigated and patterns are described.
- A technique for interpretation of Mothur interfaces has been developed and implemented.
- Transformation tools are tested in application areas and no significant technical problems were detected.
- A technique of document authoring is being developed and adapted to the domain.

The source codes are available at
https://github.com/isu-enterprise/icc.xmitransform,
https://github.com/eugeneai/icc.mothurpim.
This research is supported by Irkutsk scientific center of SB RAS, project No 4.2;

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/)
R (https://www.r-project.org/)

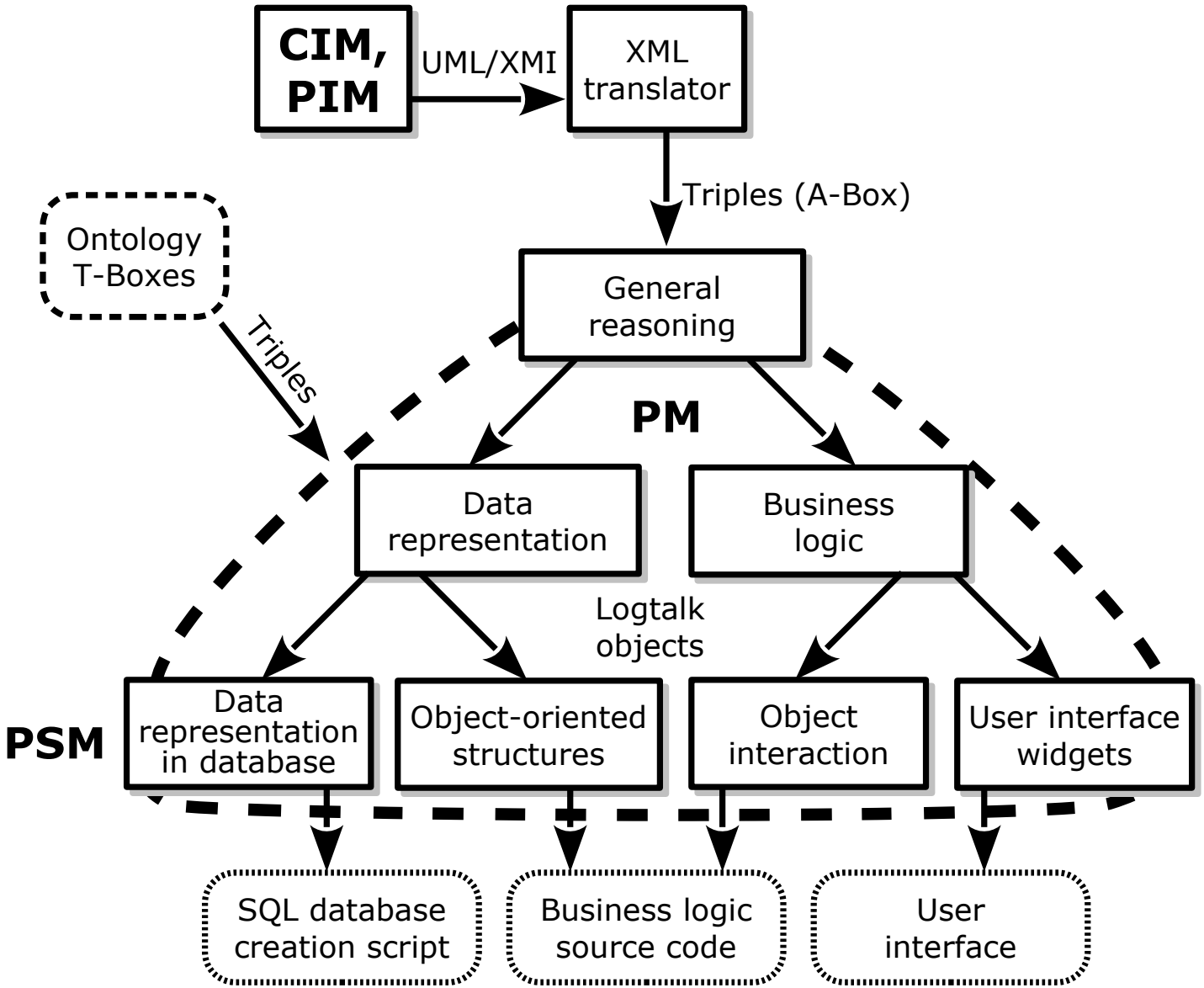
External links

This presentation

Illumina movie on NGS

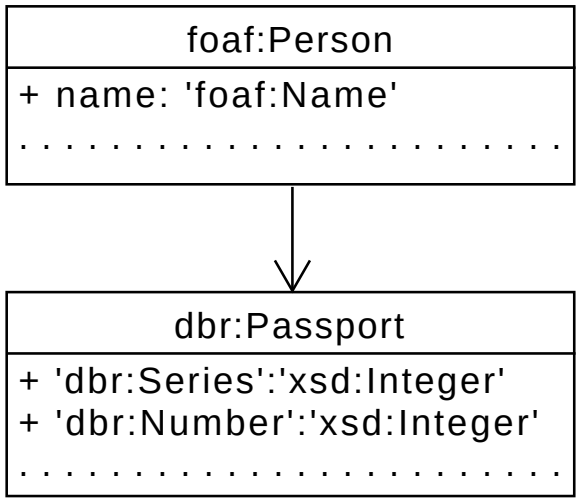
Thanks for Your interest to our project!

Architecture of transformation modules



Access LOD data

```
:- category(sparql).
:- public(query/2).
query(Pattern,Parameters,Row):-
    prepare(Pattern,Parameters,Query),
    server(Host,Port,Path),
    sparql_query(Query, Row,
        [host(Host),port(Port),path(Path)]).
:- protected(server/3).  % must be implemented
                         % by a subclass.
:- protected(prepare/3). % prepares a query
% . . . . . .           %              string.
:- end_category.

:- object(dbpedia, extends(sparql)).
:- protected(server/3).
server('dbpedia.org',80,'/sparql').
:- public(entity_name/2).
entity_name(Entity,Language,Name):-
    query('select ?name where { '
          ' %w rdfs:label ?name. '
          'FILTER langMatches( lang(?label),'
          ' "%w" )}', [Entity, Language],
          row(Name)).
:- end_object.

% ?- dbpedia::entity_name(dbr:'Passport', 'ru', Name).
```



Document authoring and storage

In most cases documents are created as a result of

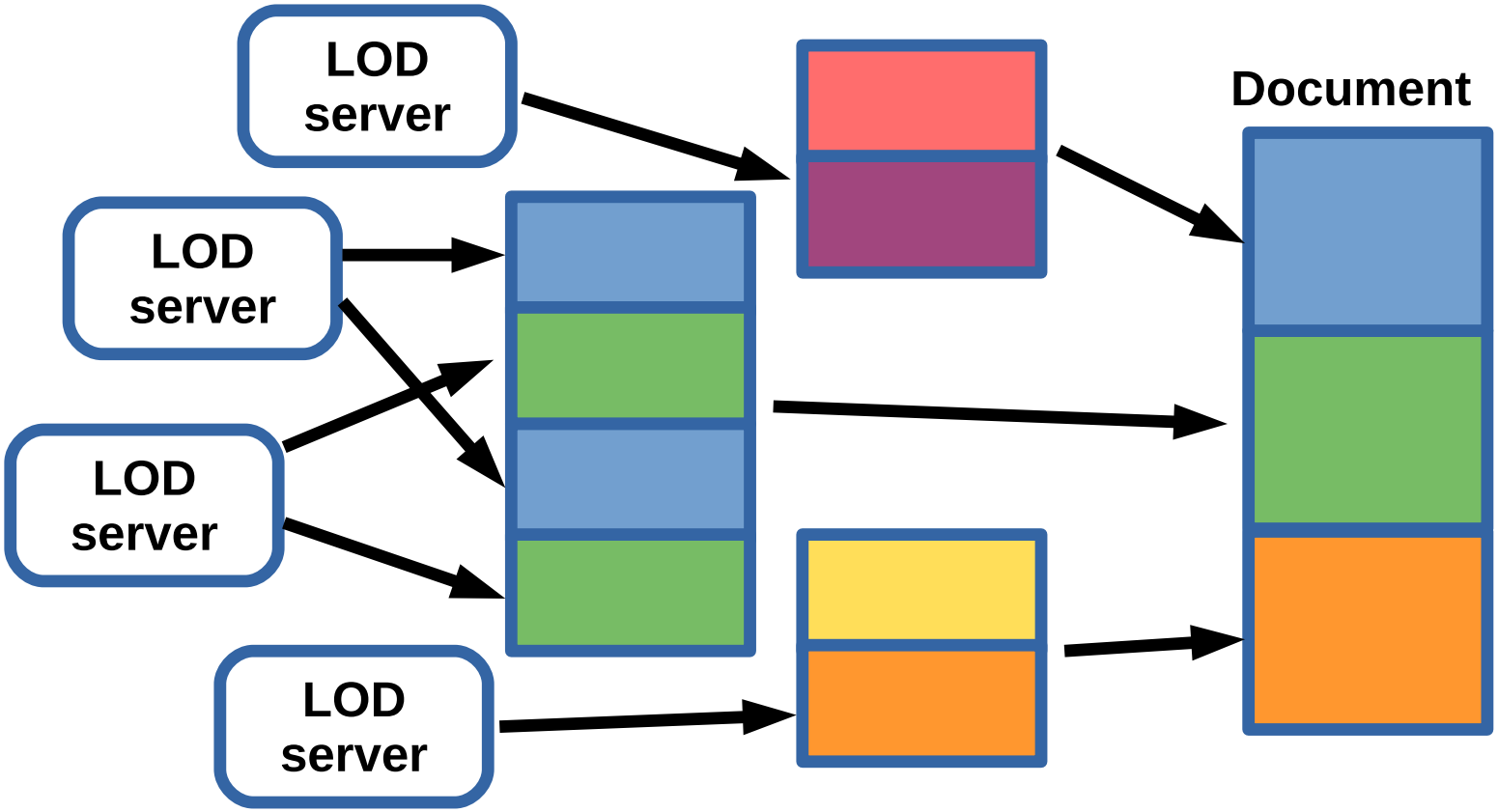
- creative activity of a person with a text processors (authoring);
- printing a digital copy or a data record in a database;
- aggregation operation over database records (report).

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

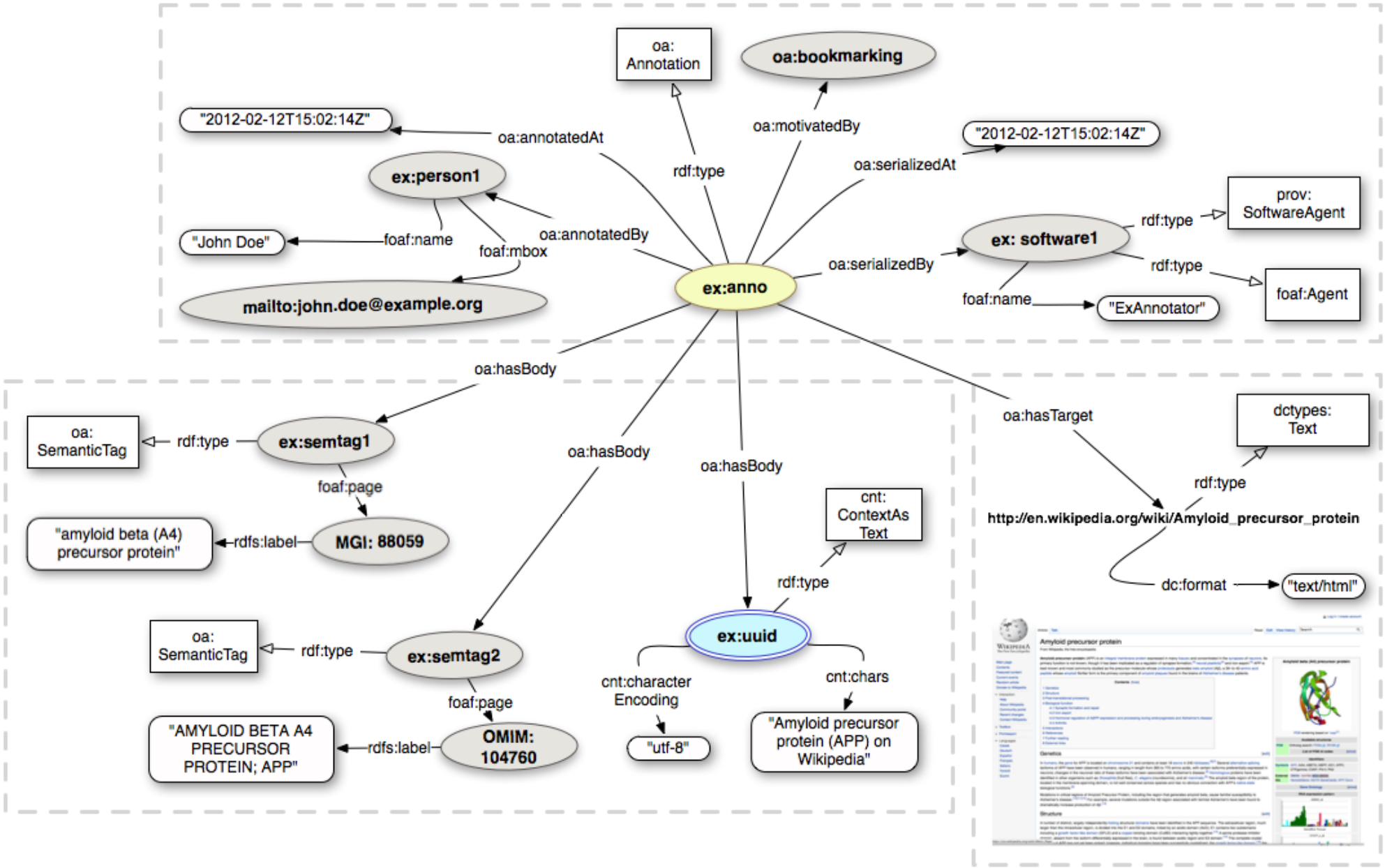
- structural storage of data within published documents;
- processing stored data computationally;
- integration of data structures and data objects globally.

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



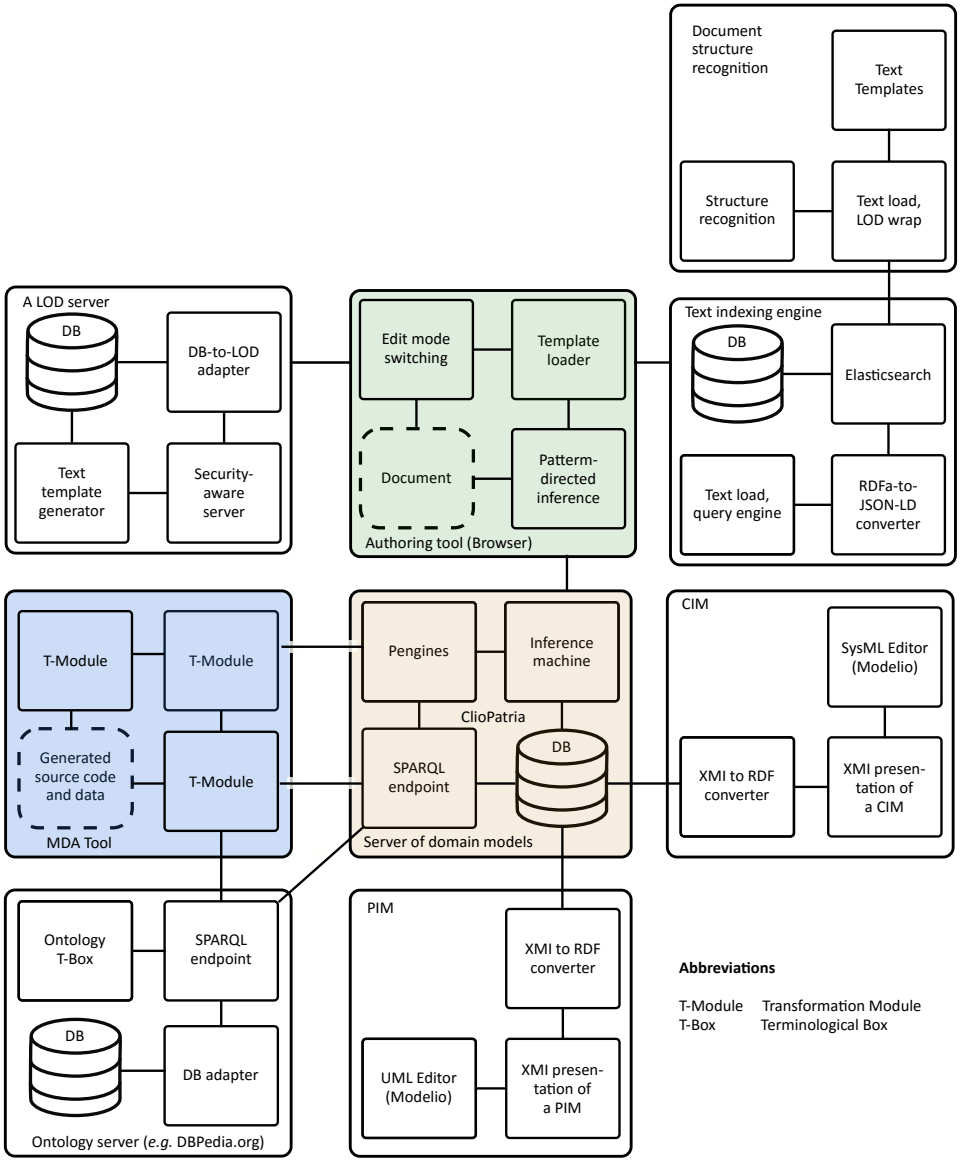
Open Annotation (oa)



Representation

```
<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>
  . . . . . .
```

Architecture



Generated list of title page preambles

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ
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ФГБОУ ВО «ИГУ»
Институт математики экономики и информатики

Кафедра информационных технологий

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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**

Complete document

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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)
2. Место дисциплины в структуре ОПОП
3. Требования к результатам освоения дисциплины (модуля)
4. Объем дисциплины (модуля) и виды учебной работы (разделяется по формам обучения)
5. Содержание дисциплины (модуля)
6. Перечень семинарских, практических занятий и лабораторных работ
7. Примерная тематика курсовых работ (проектов)
8. Учебно-методическое и информационное обеспечение дисциплины (модуля)
9. Материально-техническое обеспечение дисциплины (модуля)
10. Образовательные технологии
11. Оценочные средства (ОС)

1. Цели и задачи дисциплины (модуля)

Целю 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

Conclusion

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.

Conclusion

The following results have been obtained as for today:

- A technique for 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.