

Bachelor Thesis

von

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Programmierung einer Auswertsoftware für RNA-seq Daten

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Muttenz, Juli 2012

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1 Einleitung

1.1 Zusammenfassung

Die Vorliegende Arbeit beschreibt die Architektur und die Anwendungsmöglichkeiten einer neuen Software zur Analyse von RNA-seq Daten.

Bei der RNA-seq - Methode, werden komplementäre DNAs (cDNAs), die aus den zu untersuchenden RNAs hergestellt wurden, mit neuartigen (eng. next-generation) Technologien sequenziert. [NWS10] Die Einführung dieser neuartiger Technologien der Gen-Sequenzierung ist ein wichtiger Meilenstein auf dem Weg zu einem besseren und tieferen Verständnis der Funktionsweise der Zellen. Bei der Durchführung von RNA-seq Experimenten fallen grosse Mengen von Daten in Form von relativ kurzen Sequenzabschnitten (< 200 Basen) an. Die Sequenzdaten werden dann an die NCBI und andere zentrale Sequenzarchive (SRA - Sequence Read Archive) übermittelt. Zum heutigen Tag sind bereits grosse Mengen an Daten gesammelt worden, die nun öffentlich online verfügbar sind.

Diese Daten werden mit der bereits bekannten Genomsequenz verglichen um die Bereiche des Genoms zu finden, die transkribiert werden. Transkription wird nicht für alle Genombereiche erwartet, sondern nur dort, wo sich proteinkodierende Abschnitte bzw. Gene für RNA-Moleküle befinden. Eine Analyse der RNA-Seq Daten wird daher durch die Visualisierung der RNA-Seq Daten entscheidend unterstützt. Darüber hinaus kann die Annotation eines Genoms durch die Verfügbarkeit der Transkriptdaten verbessert werden.

Die in dieser Diplomarbeit programmierte Web-Anwendung wurde erstellt, um die von RNA-seq Experimenten generierten Daten in einer bereits existierenden, populären, Visualisierungsanwendung, dem *UCSC Archaea Browser* [Sch06], anzuzeigen. Durch die Verwendung der von dieser Anwendung unterstützten, bzw. definierten, Protokolle zur Formatierung und Darstellung der Daten, stehen dem Anwender viele Funktionen zur Verfügung, die sich mit einer gekapselten Desktop-Anwendung nur unter grossem Aufwand realisieren liessen. So können die Daten im *UCSC Archaea Browser* beispielsweise immer im Kontext mit den *aktuellen* RefSeq Gen-Annotationen betrachtet werden.

1.2 Motivation / Ziel

Der Fokus vieler RNA-seq Studien liegt in der Analyse von eukaryontischen Transkriptomen. Die generierten Sequenzdaten sind z.B. sehr hilfreich, um die unterschiedlichen Transkripte eines Gens zu erfassen.

Für die prinzipiell wesentlich einfachere Auswertung von RNA-seq Daten von Prokaryonten stehen bisher keine geeigneten Auswerteprogramme zur Verfügung.

Die Programmierung einer solchen Software im Rahmen einer Bachelor-Thesis bietet sich daher an. Zum einen erhalte ich als Student der Biomedizinischen Informatik einen Einblick in die die Welt der Genforschung. Zum andern kann

ich hoffentlich mit meiner Arbeit einen kleinen Beitrag zur Verbesserung der Zugänglichkeit zu der beeindruckenden Menge an RNA-Sequenzdaten leisten.

1.3 Theoretischer Hintergrund

Seit einiger Zeit bieten eine Handvoll Produzenten Gensequenzierungsanlagen an, bei denen die Kosten pro sequenziertem Basenpaar drastisch verringert werden konnten. Diese neuartigen Sequenzierungs-Plattformen werden dazu verwendet, sowohl das Genom wie auch das Transkriptom, also die gesamte RNA-Substanz die in einer Zelle zu einem definierten Zeitpunkt vorhanden ist, zu sequenzieren.

Gegenüber der klassischen Transkriptomanalyse mit Mikroarrays, bietet RNA-seq den gewichtigen Vorteil, dass damit *alle* Abschnitte des Genoms auf Transkription geprüft werden können.

Mit RNA-seq können darum - und das ist auch der Teil für den die vorliegende Software eingesetzt werden soll - auch *neue Gene* gefunden bzw. untranskribierte Bereiche erkannt werden, wo bisher ein Gen vermutet wurde. [CT10]

Ein weiterer Vorteil von RNA-seq Technologien, ist die Möglichkeit, das Expressionsniveau jeder einzelnen Base exakt messen zu können. Indem die Anzahl der Reads bezüglich Ihrer Länge und der Länge des Gens auf dem sie liegen normalisiert wird, werden dadurch verschiedene Studien auch sehr gut miteinander vergleichbar. [CT10; WGS09]

2 Architektur der implementierten Lösung

2.1 Technologie-Umfeld

Betriebssystem

UNIX ist aus Entwicklersicht aus verschiedenen Gründen eine optimale Betriebssystemplattform, um Datenintensive Berechnungen, wie sie bei der Verarbeitung und Aufbereitung von RNA-seq Daten anfallen durchzuführen. Die Architektur des Systems hat sich bewährt und ist weiterhin bekannt für Ihre Robustheit, Performanz.

So sind denn auch die meisten Programme, die in jüngster Vergangenheit entwickelt wurden, um RNA-seq Daten zu verarbeiten, auf UNIX Umgebungen programmiert worden und darum dort auch ohne Probleme lauffähig.

Für die Softwareentwicklung sind auf der UNIX Plattform eine Vielzahl verschiedener Programmbibliotheken und Sprachumgebungen Verfügbar. Die Qualität variiert, doch der Wettbewerb selektiert schlussendlich immer die guten.

Es wurde also ein UNIX Betriebssystem und zwar Debian GNU/Linux 6.0.4 (code-name "squeeze") verwendet.

Programmiersprache

Die Programmiersprache *Python*, für die im Jahre 1991 ein erster Interpreter publiziert wurde und die in den letzten Jahren sehr populär geworden ist, war schon gesetzt. Sie eignet sich besonders gut für die schnelle Entwicklung von spezialisierter Software, da der Quellcode nicht in einem separaten Schritt kompiliert werden muss und darum geänderter Code viel schneller getestet werden kann.

Testing

Das Testen einzelner Softwarekomponenten wird mit dem *unittest* modul, eines von unzähligen Modulen in der *Python Standard Library*, orchestriert. Das *nosetest* Modul erweitert die Funktionalität des Standard Moduls noch. Es erzeugt in Zusammenarbeit mit dem *coverage* Programmpaket auf Befehl hin einen *Test Coverage Report*. Die Test-Coverage lässt sich als Prozentzahl angeben. Sie gibt Auskunft darüber, wie gross der Anteil der getesteten Code-Statements im Vergleich zur Gesamtzahl von Code-Statements ist.

weitere Bausteine

Bei der Auswahl der Technologien zur Implementation der vorliegende Software, habe ich versucht möglichst solche Bausteine und Bibliotheken zu verwenden, die gut dokumentiert sind, eine möglichst grosse Anwenderbasis haben und sich bereits möglichst lange im Wettbewerb behaupten konnten.

2.2 Systemdesing

Das

2.3 Komponenten

2.4 Erfahrungsbericht

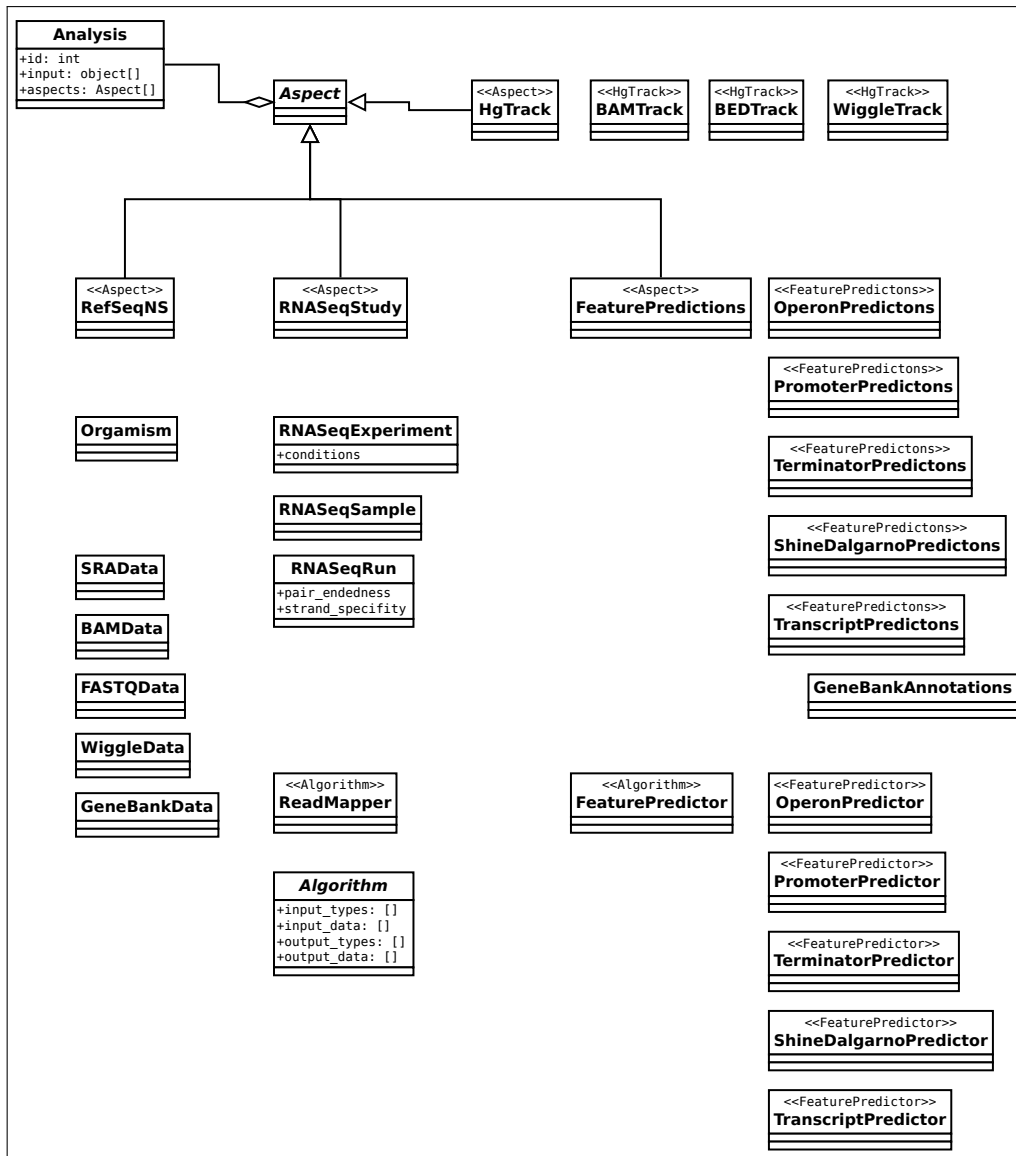


Abb. 1: Foo

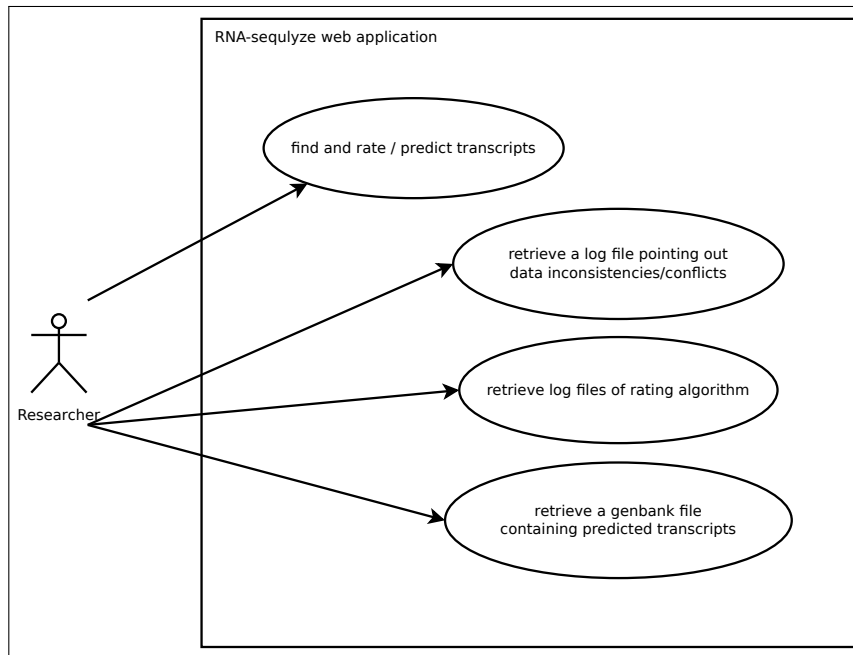


Abb. 2: Bar

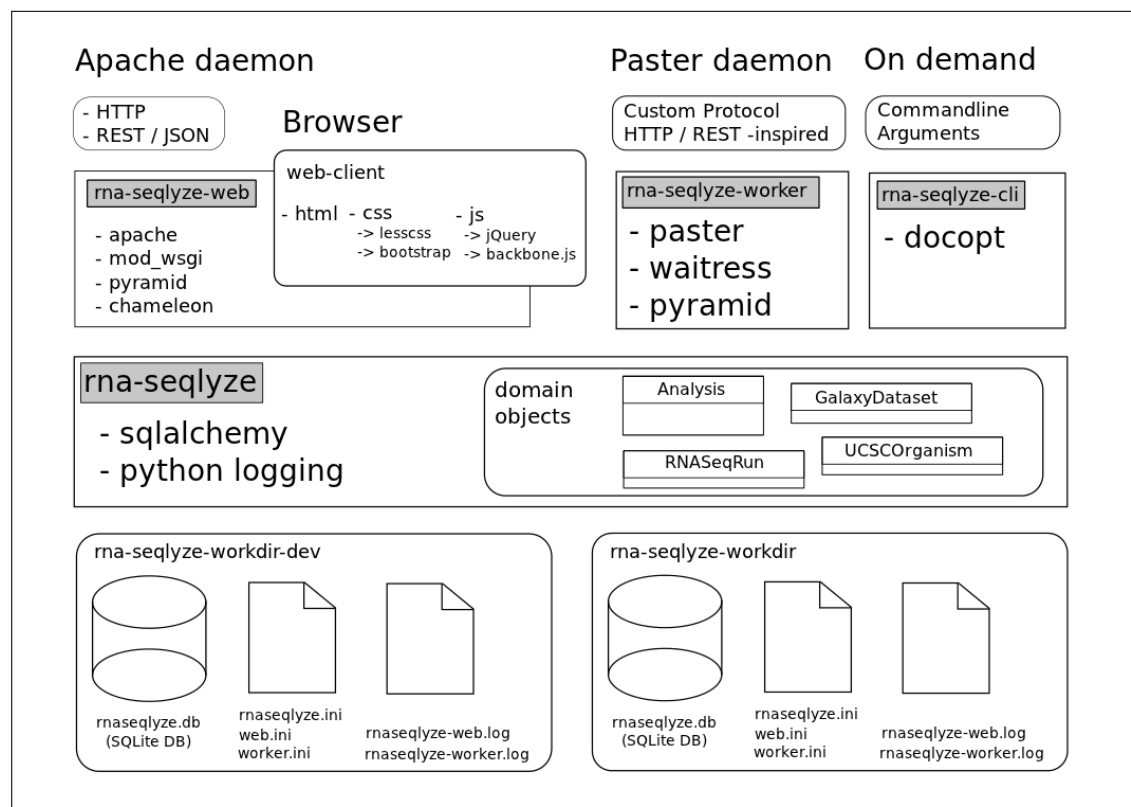


Abb. 3: Übersicht der Architektur der RNA-Seqlyze Applikation. Zuunterst die Konfigurations- und Datenbank- Dateien. In der Mitte die Kernfunktionalität, mit SQLAlchemy als 3.3Object-Relational Mapper. Darüber die einzelnen Schnittstellen. Dann die von den Schnittstellen verwendeten Protokolle. Zuoberst die den Code ausführenden Prozesse.

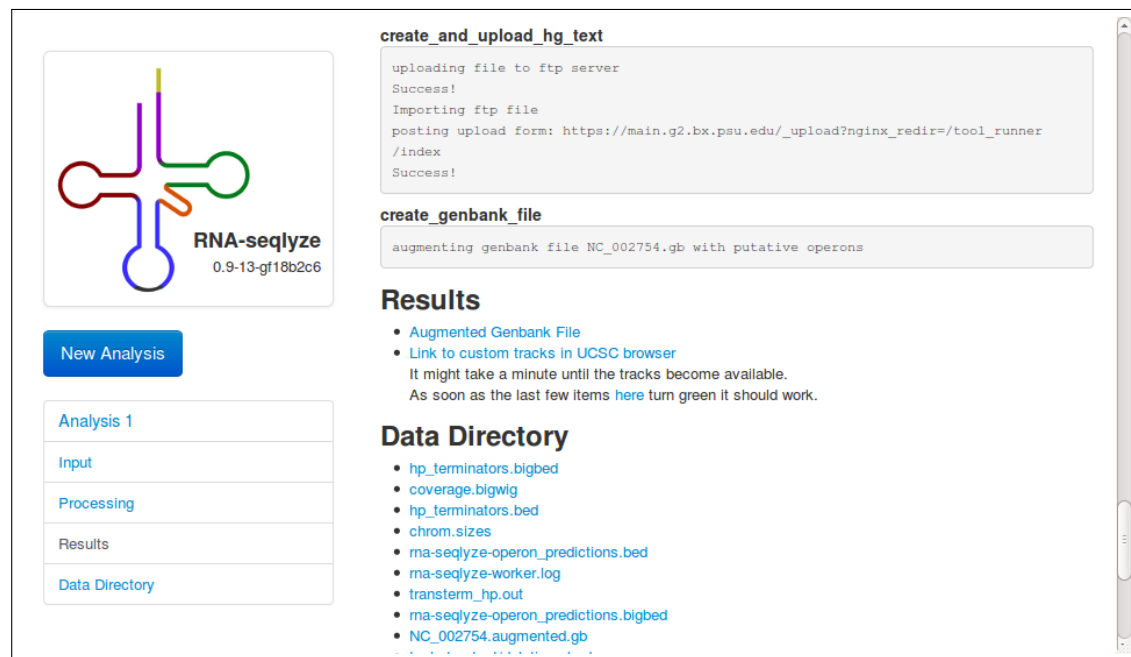


Abb. 4: Darstellung einer bereits beendeten Analyse. Der graue Hintergrund der Log-Ausgaben des letzten Analyseschrittes zeigt an, dass die Analyse beendet ist. Unter der Überschrift "Results" finden sich ein Link zum UCSC Genom Browser, wo die Resultate angezeigt werden können und ein Link zu einer Genbank Datei, in der die gefundenen Operons annotiert wurden.

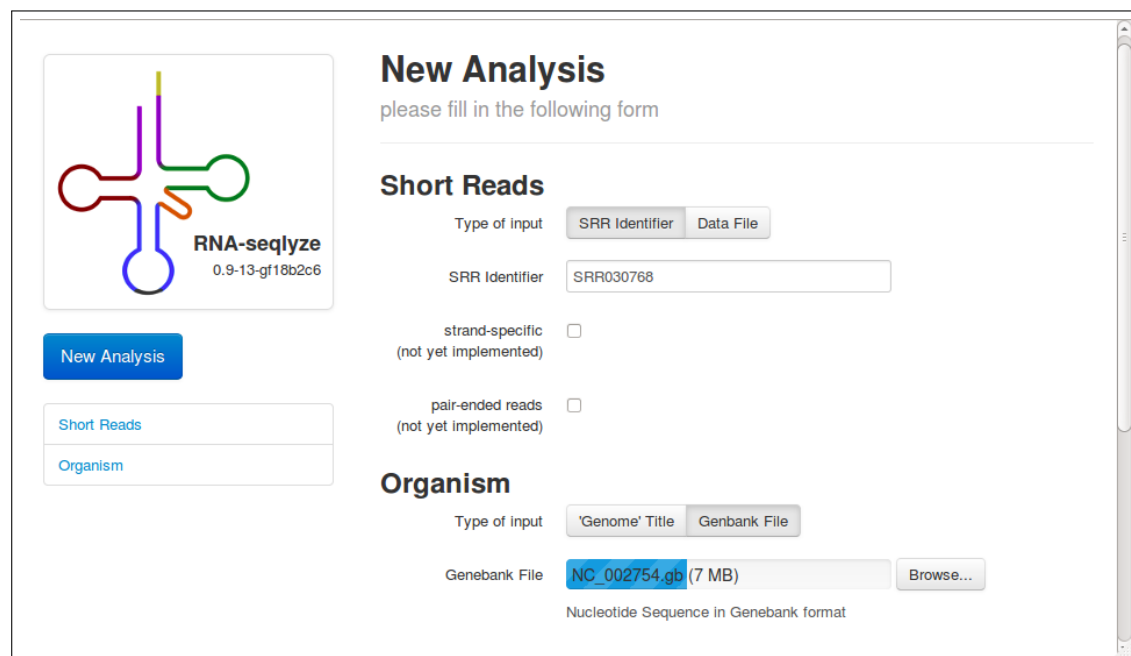


Abb. 5: Starten einer neuen Analyse. Benötigt werden Short Read Daten und die Referenzsequenz. Für beide Inputs kann entweder die NCBI Identifikationsnummer angegeben oder eine Datei direkt hochgeladen werden.

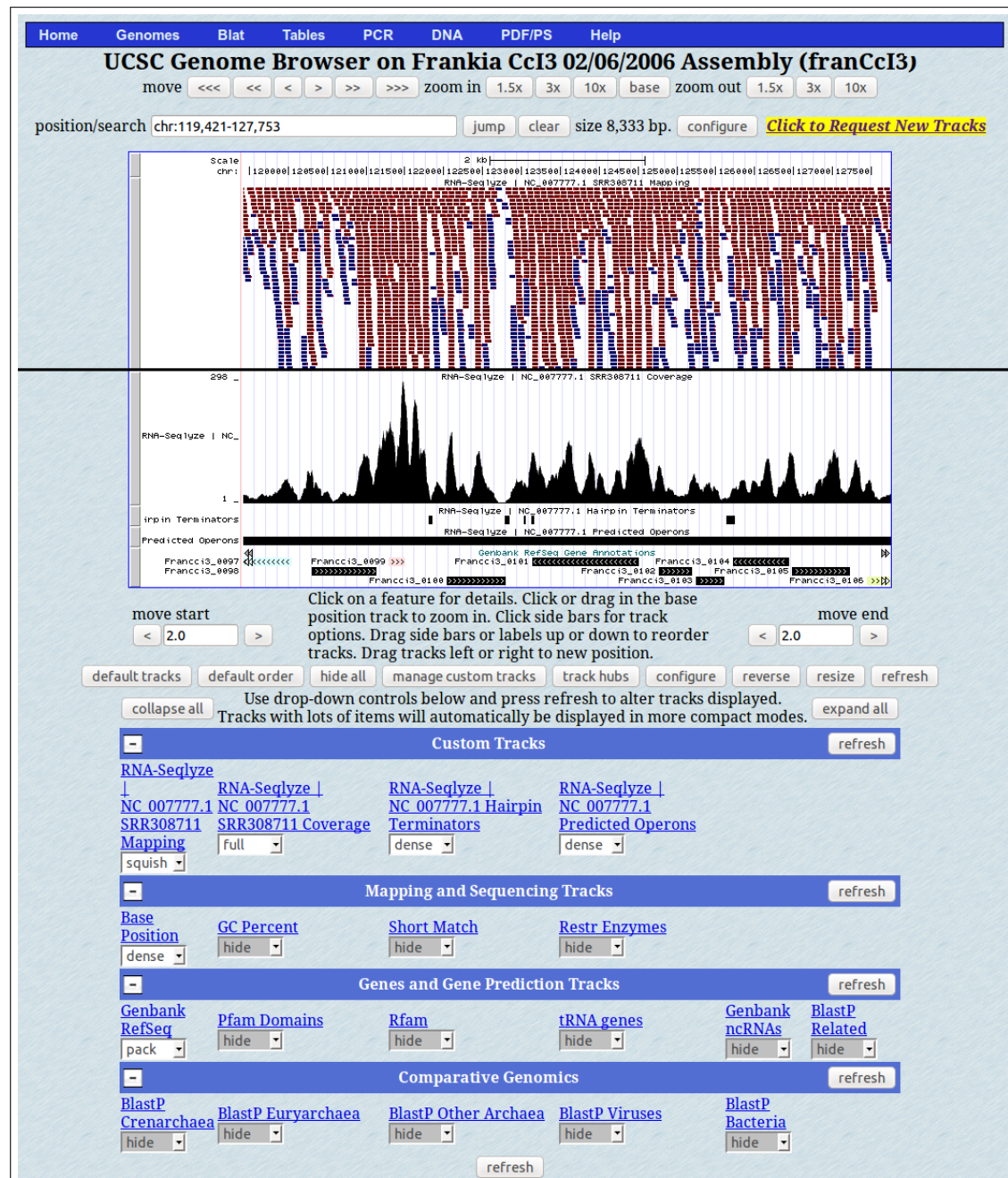


Abb. 6: UCSC Browser...

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3.1 Quellcode

3.1.1 Package rnaseqlyze

Modul rnaseqlyze

```

"""
Top level package module

Importing this package configures the python "logging"
5 module in a way that messages of any level go to sys.stderr.
"""

#: the project base-name
#: the -cli, -web and -worker project names
10 #: are constructed by appending the part name to this one
project_name = "rna-seqlyze"

import pkg_resources
#: The __version__ property is set automatically set to the value of
15 #: pkg_resources.get_distribution(project_name).version on module import time.
try:
    __version__ = pkg_resources.get_distribution(project_name).version
except:
    # When the packe is initially installed, this module is imported by setup.py
    # and the the `project_name` attribute defined above is used to set the
    # project name, in order to make that information non-redundant.
    #
    # The version, however, is determined at install/build time by running
    # `git --describe` - in setup.py. So it doesn't matter if it is not set at
    # that time. Later on, because `python setup.py install/develop` writes it
    # to rna-seqlyze.egg-info/PKG-INFO, where pkg_resources picks it up,
    # it will be available whenever the package is imported.
    pass
del pkg_resources

30 import logging
logging.basicConfig(level=0, format="%(levelname)-5.5s [% (name)s] %(message)s")
del logging

35 def configure(_workdir):
    """
    Calling this function

    - sets rnaseqlyze.workdir to <workdir>

40
    - sets rnaseqlyze.<setting> attributes for all
      settings under [rnaseqlyze] in '<workdir>/rnaseqlyze.ini'.

```

```

    - imports Bio.Entrez and sets Bio.Entrez.email to rnaseqlyze.admin_email
45  """

    global workdir
    workdir = _workdir

50  from os.path import join
    from ConfigParser import ConfigParser
    config = ConfigParser(dict(here=workdir))
    config.read(join(workdir, 'rnaseqlyze.ini'))

55  for name, value in config.items("rnaseqlyze"):
        globals()[name] = value

    import Bio.Entrez
    Bio.Entrez.email = admin_email
```

Modul rnaseqlyze.build

```

    """
    The rna-seqlyze software consisty of several parts. The majority of those parts
    have been developped independtly of this project and have been released under
    a permissive license that allows them to be used in other (permissive licenced)
5  projects like this one.

    This file defines a simple system and stores the commands necessary to build and
    install those third-party components.
    """

10  from __future__ import print_function

    import os, sys, shutil
    from os import environ as env
15  from types import MethodType
    import subprocess, multiprocessing

    # a bit of infrastructure
    #####

20  class PartType(type):

        def __init__(cls, *ign):
            """
            auto-create and stock instances
            upon creation of "Part" (sub)classes

            appends a new instance of the
            created class to the "parts" list, if it exists
            """
30  try:
            parts.append(cls())
        except NameError:
            pass
```

```

35 class Part(object):

    __metaclass__ = PartType

40 def __init__(self):
    self.name = self.__class__.__name__
    try:
        self.subdir = "src/" + self.srcdir
    except AttributeError:
45         self.subdir = "src/" + self.name

    def execute(self, phase):
        cmds = getattr(self, phase, None)
        if cmds == None: return
50 print("#" * 80)
        print("# executing %s '%s' phase" % (self.name, phase))
        print("#")
        dev_null = file("/dev/null")
        logdir = "report/buildlogs"
55 if not os.path.isdir(logdir): os.mkdir(logdir)
        logpath = logdir + "/%s-%s.log" % (self.name, phase)
        T = subprocess.Popen(["tee", logpath], stdin=subprocess.PIPE)
        try:
            import time
            log = lambda msg="": print(msg, file=T.stdin)
            log(time.asctime())
            log()
            log("\n".join("%s=%s" % nv
60 for nv in filter(lambda i: i[0] in (
                "TOPDIR", "PREFIX", "BINDIR", "LIBDIR",
65 "MACHTYPE", "NCPUS_ONLN"), env.iteritems()))
            log()
            if type(cmds) not in (list, tuple):
                cmds = cmds, # make it a 1-tuple
70 for cmd in cmds:
                log("$ cd " + self.subdir)
                log("$ " + "\n ".join(str(cmd).split("\n")))
                log()
                if type(cmd) == str:
75 ret = subprocess.call(cmd, shell=True, cwd=self.subdir,
                    stdin=dev_null, stdout=T.stdin, stderr=T.stdin)
                elif type(cmd) == MethodType:
                    def tgt():
                        sys.stdin = dev_null
                        sys.stdout = sys.stderr = T.stdin
80 os.chdir(self.subdir)
                        return cmd()
                    sp = multiprocessing.Process(target=tgt)
                    sp.start()
85 sp.join()
                    ret = sp.exitcode
                else:
                    raise Exception("Invalid '%s' phase command: %s" % (

```

```

phase, repr(cmd)))
90         log()
        log(time.asctime())
        if ret != 0:
            raise Exception("%s '%s' phase failed -- exit code %d" % (
                self.name, phase, ret))
95     finally:
        T.stdin.close()
        T.wait()

    # parts & phases
100    #####

    parts = []
    phases = 'build', 'test', 'install'

105    class bcbdb(Part):
        srcdir = "bcbdb/nextgen"
        build = "python setup.py build"
        # save some time
        #test = "nosetests"
110        install = "python setup.py install --prefix=$PREFIX"

    class biopython(Part):
        build = "python setup.py build"
        # save some time
115        #test = "python setup.py test"
        install = "python setup.py install --prefix=$PREFIX"

    class bowtie2(Part):
        build = "make -j$NCPUS_ONLN"
120        def install(self):
            """
            the bowtie2 install function
            exists because there is no 'install' target in
            the makefile, so the binaries need to be installed manually
125            """
            import shutil
            for f in ("bowtie2" + x for x in ("", "-align", "-build", "-inspect")):
                shutil.copy(f, env["BINDIR"])
                os.chmod(env["BINDIR"] + "/" + f, 0775)
130

    class ncurses(Part):
        build = "./configure --prefix $HOME/.local && make"
        install = "make install"

135    class samtools(Part):
        depends = ncurses
        build = (
            'make -j$NCPUS_ONLN -C bcftools',
            'make -j2 SUBDIRS=.'
140            ' LIBPATH=-L$PREFIX/lib LIBCURSES=-lncurses'
            ' CFLAGS="$(echo -I$PREFIX/include{,/ncurses})"'
        )

```

```

install = "cp samtools $PREFIX/bin"

145 class cufflinks(Part):
    depends = samtools
    build = "./configure --prefix=$PREFIX" \
           " --with-eigen=$TOPDIR/src/eigen" \
           " --with-bam=$TOPDIR/src/samtools && make"
150 install = "make install"

class kent(Part):
    build = "make -C src/lib"
    def install(self):
155         """
            the kent install function was created, because rna-seqlyze need only
            a small subset of the included utilities and the easiest way to build
            those is to run "make" with custom arguments for each one of them
            """
160         for util in "wigToBigWig bedToBigBed".split(" "):
            if subprocess.call("make -C src/utis/" + util, shell=True) != 0:
                raise Exception("kent.install(): couldn't install '%s'" % util)

class pysam(Part):
165     build = "python setup.py build"
    # tests failing...
    #test = "cd tests; nosetests --exe"
    #test = "cd tests; ./pysam_test.py"
    install = "python setup.py install --prefix=$PREFIX"
170

class rna_seqlyze_cli(Part):
    srcdir = "rna-seqlyze-cli"
    build = "python setup.py build"
    test = "python setup.py test"
175 install = "python setup.py develop --prefix=$PREFIX"

class rna_seqlyze_web(Part):
    srcdir = "rna-seqlyze-web"
    build = "python setup.py build"
180 test = "python setup.py test"
    install = "python setup.py develop --prefix=$PREFIX"

class rna_seqlyze_worker(Part):
    srcdir = "rna-seqlyze-worker"
185 build = "python setup.py build"
    test = "python setup.py test"
    install = "python setup.py develop --prefix=$PREFIX"

class sra_sdk(Part):
190     # To get this to compile, I
    # 1) created a symlink src/sra_sdk/libxml2.so
    #    pointing to /usr/lib/libxml2.so.2 and added
    #    LDFLAGS=-L$PWD to avoid having to install libxml2-dev
    # 2) replaced the content of src/sra_sdk/libs/ext/Makefile
195     #    with "all:" to skip unnecessary downloading of zlib and libbz2
    build = "LD_RUN_PATH=$LIBDIR make STATIC= STATICSYSLIBS= LDFLAGS=-L$PWD"

```

```

install = (
    "cp -a linux/pub/gcc/$ARCH/bin/* $BINDIR",
    "cp -a linux/pub/gcc/$ARCH/lib/* $LIBDIR",
200    "cp -a linux/pub/gcc/$ARCH/mod $LIBDIR/ncbi",
    "cp -a linux/pub/gcc/$ARCH/wmod $LIBDIR/ncbi",
)

class tophat(Part):
205    build = "./configure --prefix=$PREFIX" \
            " --with-bam=$TOPDIR/src/samtools && make"
    install = "make install"

class trac(Part):
210    build = "python setup.py build"
    # save some time
    #test = "python setup.py test"
    install = "python setup.py install --prefix=$PREFIX"

215 class trac_env(Part):
    def install(self):
        # need to discuss server
        # configuration with admin
        #destdir = "%(PREFIX)s/var/trac_env" % env
220        #basedir = os.path.dirname(destdir)
        #if not os.path.isdir(basedir):
        #    os.mkdir(basedir)
        #shutil.copytree(".", destdir, symlinks=True)
        #print("Copied %s to %s\n" % (os.getcwd(), destdir))
225        print("\n".join(
            """\
The following still needs to be done manually:
1) Set up a database
2) Restore the backup:
230    $ cd """ + os.getcwd() + """
    $ mysql -uUSERNAME -pPASSWORD DATABASE < mysql-db-backup.sql
4) Adjust the 'database' variable in the [trac] section in 'conf/trac.ini':
    database = mysql://USERNAME:PASSWORD@localhost/DATABASE
"""
        )))
235    )))

class transterm_hp(Part):
    build = "make"
    def install(self):
240        prog = "transterm"
        data = "expterm.dat"
        shutil.copy(prog, env["BINDIR"])
        os.chmod(env["BINDIR"] + "/" + prog, 0775)
        shutil.copy(data, env["LIBDIR"])
245

class s3cmd(Part):
    install = "python setup.py install --prefix=$PREFIX"

class docopt(Part):
250    install = "python setup.py install --prefix=$PREFIX"

```


Modul rnaseqlyze.efetch

```

from Bio import Entrez

import rnaseqlyze

5 nc_db = "nuccore"
  gb_type = "gb"
  gb_mode = "text"

def get_nc_id(accession):
10     handle = Entrez.esearch(db=nc_db, term=accession + "[Accession]")
      id_list = Entrez.read(handle)["IdList"]
      if len(id_list) != 1:
          raise Exception("unexpected reply from Entrez: id_list: %s" % id_list)
      return id_list[0]

15 def fetch_nc_gb(gb_id, out_file):
      handle = Entrez.efetch(db=nc_db, id=gb_id, rettype=gb_type, retmode=gb_mode)
      from shutil import copyfileobj as copy
      copy(handle, out_file)

```

Modul rnaseqlyze.galaxy

```

"""
RNA-Seqlyze Galaxy Module

Shamelessly piggy-back onto Penn-State University's "Galaxy" Project.

5 RNA-Seqlyze needs a some publicly available Web-Space, which PSU provides
  plenty of for bioinformatics reseach data (250.0 Gb per user as of 4 Jul 2012).

  Thanks go to Penn-State University!

10 http://www.psu.edu/

"""

15 # FIXME: the whole code here needs heavy refactoring

import logging
log = logging.getLogger(__name__)

20 import os, json, time, ftplib, \
      urllib, urllib2, cookielib
from time import time
from threading import local
from datetime import datetime, timedelta

25 import lxml.html

import rnaseqlyze
from rnaseqlyze import multipart

30

```

```

email = 'ucgxcccgr@mailinator.com'
password = 'brtbhcdg'
api_key = 'dddb2c53c96c0c4d263e6c74b507d203'
hostname = 'main.g2.bx.psu.edu'

35 default_history = '16f9a8e916e0e908'

default_history_url = 'https://main.g2.bx.psu.edu/u/dcgdfvtvcdv/h/rna-seqlyze'

40 history_path_template = '/api/histories/{history}/contents'
ucsc_bam_track_template = \
    '/display_application/{dataset}/ucsc_bam/archaea/None/param/track'

ucsc_bam_path_template = \
45     '/display_application/{dataset}/' \
    'ucsc_bam/archaea/None/data/galaxy_{dataset}.bam'

dataset_info_url_template = "/api/histories/{history}/contents/{dataset}"

50 dataset_display_url_template = "/datasets/{dataset}/display"

rq_headers = {}

class Session(local):
55     cookies = None
    created = None

    session = Session()

60 def api_call(path):
    url = "https://" + hostname + path
    return urllib2.urlopen(url + "?key=" + api_key).read()

def login():
65     cookie_jar = cookielib.CookieJar()
    urllib2.install_opener(urllib2.build_opener(
        urllib2.HTTPCookieProcessor(cookie_jar)))
    log.info("Loggin in to galaxy server %s ..." % hostname)
    login = "https://" + hostname + "/user/login"
70     rq = urllib2.Request(login, headers=rq_headers)
    request = urllib2.urlopen(rq)
    doc = lxml.html.parse(request).getroot()
    form = doc.forms[0]
    form.fields["email"] = email
75     form.fields["password"] = password
    submit = "login_button", form.fields["login_button"]
    data = urllib.urlencode(form.form_values() + [submit])
    log.debug("posting login form: %s" % form.action)
    rq = urllib2.Request(form.action, headers=rq_headers)
80     request = urllib2.urlopen(rq, data)
    doc = lxml.html.parse(request).getroot()
    log.info("Success!")
    return cookie_jar

```

```

85 def import_upload(filename):
    if not (session.created
            and session.created > (datetime.now() - timedelta(minutes=30))):
        session.cookies = login()
        session.created = datetime.now()

90
    urllib2.install_opener(urllib2.build_opener(
        urllib2.HTTPCookieProcessor(session.cookies)))
    log.info("Importing ftp file")
    tool = "https://" + hostname + "/tool_runner?tool_id=upload1"
95    rq = urllib2.Request(tool, headers=rq_headers)
    request = urllib2.urlopen(rq)
    doc = lxml.html.parse(request).getroot()
    found = False
    form = doc.forms[0]
100    inp = form.inputs["files_0|ftp_files"]
    if isinstance(inp, lxml.html.InputElement):
        if inp.attrib['value'] == filename:
            found = inp.checked = True
    elif isinstance(inp, lxml.html.CheckboxGroup):
105        for box in inp:
            if box.attrib['value'] == filename:
                found = box.checked = True
    else:
        raise Exception("unexpected html element: %s" % inp)
110    if not found:
        raise Exception("file not available for import: %s" % filename)
    submit = "runtool_btn", form.fields["runtool_btn"]
    data = multipart.urlencode(form.form_values() + [submit])
    log.debug("posting upload form: %s" % form.action)
115    rq = urllib2.Request(form.action, data, headers=rq_headers)
    request = multipart.urlopen(rq)
    doc = lxml.html.parse(request).getroot()
    log.info("Success!")

120 def ftpupload(fileobj, filename):
    """
    upload a file object to galaxy
    based on http://love-python.blogspot.com/2008/02/ftp-file-upload.html
    """
125    log.info("uploading file to ftp server")
    ftp = ftplib.FTP(hostname, email, password)

    try:
        total = os.stat(fileobj.name).st_size
130    except:
        total = 0

    class cbc(object):
        def __init__(self, total):
135            self.total = total
            self.sent = 0
            self.then = time()
        def __call__(self, buf):

```

```

        self.sent += len(buf)
        now = time()
        if self.then < now - 15:
            self.then = now
            log.info("%d kb left" % ((self.total - self.sent) / 1024))

log.info("sending %d kb of data..." % ((total / 1024 or -1)))
ftp.storbinary('STOR ' + filename, fileobj, callback=cbc(total))
log.info("Success!")
ftp.quit()

150 def upload(fileobj, filename):

    # can't initialize this at module import time
    # because rnaseqlyze.xxx properties not initialized
    global rq_headers
155     try:
        mail = rnaseqlyze.admin_email
    except:
        # rnaseqlyze not .configure()d
        mail = os.getenv("USER") + "@" + os.uname()[1]
160     rq_headers = {
        'User-Agent': "%s (version:%s / admin:%s)" % (
            rnaseqlyze.project_name, rnaseqlyze.__version__, mail),
        # 'User-Agent': "Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:13.0)" \
        # " Gecko/20100101 Firefox/13.0.1",
165     }

    ftpupload(fileobj, filename)
    import_upload(filename)
    datasets = json.loads(api_call(
170         history_path_template.format(history=default_history)))
    # assume objects are ordered chronologically...
    for dataset in reversed(datasets):
        if dataset['name'] == filename:
            return dataset['id']
175     raise Exception("Couldn't find id of uploaded file in dataset")

```

Modul rnaseqlyze.gb2ptt

```

import logging
log = logging.getLogger(__name__)

import sys

5
from Bio import SeqIO
from Bio.SeqFeature import ExactPosition

def gb2ptt(in_file, out_file):
10
    debug = False

    seq = SeqIO.parse(in_file, "genbank").next()

```

```

15     # expected input:
    #
    # CDS 249..857
    #     /locus_tag="SS00001"
    #     /note="Predicted membrane protein, conserved in archaea"
20     #     /codon_start=1
    #     /transl_table=11
    #     /product="hypothetical protein"
    #     /protein_id="NP_341578.1"
    #     /db_xref="GI:15896973"
25     #     /db_xref="GeneID:1455258"
    #     /translation="MITEFLLKKKLEEHLSHVKEENTYVTDLVRCPRRVRYESEYKE
    #     LAISQVYAPSAILGDILHLGLESVLKGNFNAETEVEITLREINVGGKVYKIKGRADAI
    #     RNDNGKSIVIEIKTSRSDKGLPLIHHKMLQIYLLWLFSAEKGILVYITPDRIAIEYEIN
    #     EPLDEATIVRLAEDTIMLQNSPRFNWECKYCIFSVCAPAKLT"
30
    # intended output:
    #
    # Sulfolobus solfataricus P2 chromosome, complete genome - 1..2992245
    # 2978 proteins
35     # Location      Strand  Length  PID
    # 249..857        +        202     15896973

    #      Gene      Synonym Code      COG      Product
    #      -        SS00001 -        COG1468L      hypothetical protein
40
import csv
writer = csv.writer(out_file, delimiter='\t', lineterminator='\n')
writer.writerow((seq.description,))
writer.writerow(())
45     writer.writerow(('Location', 'Strand', 'Length', 'PID',
        'Gene', 'Synonym', 'Code', 'COG', 'Product'))

n=0
for f in seq.features:
50
    n+=1
    if debug and n > 10:
        break

55     if f.type != 'CDS':
        continue

    if type(f.location.start) != ExactPosition \
    or type(f.location.end) != ExactPosition:
60         log.info("skipping non-exact location '%s' in '%s'" % (
            f.location, f.type))

        continue

    _len = f.location.end.position - f.location.start.position
65     if _len < 0:
        _len = len(seq.seq) \
            - f.location.start.position + f.location.end.position
    if _len % 3:

```

```

    log.info("implausible feature length (%d) in '%s'" % (_len, f.type))
70  _len //= 3 # integer division
    _len -= 1 # omit stop codon

    xrefs = dict(map(lambda s: s.split(':'), f.qualifiers['db_xref']))
    for r in 'GI', 'GeneID':
75         if r not in xrefs:
            xrefs[r] = '-'

    for q in 'gene', 'product', 'locus_tag':
        if q not in f.qualifiers:
80             f.qualifiers[q] = '-'

    # need to convert between biopython (0-based, incl:excl)
    # and genbank (1-based, incl:incl) position boundary notation here
    writer.writerow((
85         "%d..%d" % (f.location.start.position+1, f.location.end.position),
        ['-', '+][(f.strand + 1) / 2],
        _len,
        xrefs['GI'],
        f.qualifiers['gene'][0],
90         f.qualifiers['locus_tag'][0],
        '-',
        '-',
        f.qualifiers['product'][0]
    ))
95

log.info("wrote %d rows" % n)

```

Modul rnaseqlyze.install

```

"""
RNA-Seqlyze Install

This command builds and installs all software components
5 included with and required by the RNA-Seqlyze web application.

Usage:
    rnas-install
    rnas-install --prefix <dir>
10    rnas-install -h|--help

Note:
    The command has must run from the top level RNA-Seqlyze source directory.

15 Options:
    --prefix <dir>

        The option is passed on to the ./configure and install
        scripts of the various programs that this command installs.
        The effect is, that all produced executables will be
20 installed under the that directory.

    If not specified, defaults to ``$HOME/.local``

```

```

25  .. important::
    The `PREFIX` variable in the "/etc/init.d/rnaseqlyze.sh"
    worker daemon startup script and the `prefix` variable
    in the "/var/www/./rna-seqlyze.wsgi" script must both
    be set to the directory specified here!

    """
30
    import os, re
    from os import environ as env
    from os.path import join, exists

35  from rnaseqlyze.build import parts, phases

    def main():
        import docopt
        opts = docopt.docopt(__doc__)

40
        assert exists("src/rna-seqlyze/rnaseqlyze/__init__.py"), \
            "This command must be run from the top level RNA-Seqlyze source directory!"

        topdir = os.getcwd()
45  prefix = opts['--prefix'] \
            or join(os.getenv("HOME"), ".local")

        env["TOPDIR"] = topdir
        env["PREFIX"] = prefix
50  env["BINDIR"] = prefix + "/bin"
        env["LIBDIR"] = prefix + "/lib"
        env["MACHTYPE"] = os.uname()[4]
        env["ARCH"] = re.sub('i.86', 'i386', env["MACHTYPE"])
        env["NCPUS_ONLN"] = str(os.sysconf("SC_NPROCESSORS_ONLN"))

55
        for part in parts:
            for phase in phases:
                part.execute(phase)

60  print "RNA-Seqlyze sucessfully installed."
        print
        print "    PREFIX=%s" % prefix
        print

```

Modul rnaseqlyze.multipart

```

    """
    Multipart form-data handling
    based on http://code.activestate.com/recipes/146306/
    """
5  import uuid, urllib2, mimetypes

    def urlopen(url, data=None):
        if isinstance(url, basestring):
            rq = urllib2.Request(url, data)
10  elif isinstance(url, urllib2.Request):

```

```

    rq = url
    data = rq.data
else:
    raise Exception("'url' parameter must be a string or urllib2.Request")
15
try:
    boundary = data[2:data.index("\r")]
except ValueError, e:
    raise Exception("couldn't find boundary string in data", e)
20
rq.add_header('Content-Type', 'multipart/form-data; boundary=%s' % boundary)
return urllib2.urlopen(rq)

def urlencode(fields, files=None):
    """
    25
    :param asd:
        is a sequence of ``(name, value)`` elements for regular form fields.

    :param files:
        is a sequence of ``(name, filename, value)``
    30
        elements for data to be uploaded as files

    :returns:
        ``str`` of **multipart/form-data** encoded fields + files
    """
    35
    boundary = str(uuid.uuid4())
    data = []
    for (key, value) in fields:
        data.append('--' + boundary)
        data.append('Content-Disposition: form-data; name="%s"' % key)
    40
        data.append('')
        data.append(value)
    if files:
        for (key, filename, value) in files:
            data.append('--' + boundary)
            data.append('Content-Disposition: form-data' \
                45
                '\n        ; name="%s"; filename="%s"' % (key, filename))
            data.append('Content-Type: %s' % get_content_type(filename))
            data.append('')
            data.append(value)
    50
    data.append('--' + boundary + '--')
    data.append('')

    return '\r\n'.join(data)

55
def get_content_type(filename):
    return mimetypes.guess_type(filename)[0] or 'application/octet-stream'

```

Modul rnaseqlyze.org.cache

```

    """
    RNA-Seqlyze keeps a cache of organisms available
    in the UCSC Browser. In addition to that, for each of
    those organisms, the matching refseq accession is cached.
    5
    """

```



```

import logging
log = logging.getLogger(__name__)

import csv
import difflib
10 from pkg_resources import resource_stream

from Bio import Entrez

15 from rnaseqlyze import ucscbrowser
from rnaseqlyze.core.entities import UCSCOrganism

prokaryotes_tsv = "refseq-data/prokaryotes.txt"

20 def refresh(db_session):
    """
    Refresh the organism cache.

    The cache is initialized from the list of organisms available in the
    25 UCSC genome browser. A list of rnaseqlyze.orm.UCSCOrganism's is
    retrieved by calling rnaseqlyze.ucscbrowser.get_org_list().

    The retrieved list is not ready to be .add()ed to the :param:db_session
    however, because the objects' primary keys, the refseq accession,
    30 are still missing.

    Those are determined by parsing the list of complete genomes available in
    the ncbi "genome" database, which is stored in

    35 rnaseqlyze/refseq-data/prokaryotes.txt

    The file was retrieved from

    ftp://ftp.ncbi.nih.gov/genomes/GENOME_REPORTS/prokaryotes.txt
    40 on Mon, 02 Jul 2012.

    Once found, the rnaseqlyze.orm.UCSCOrganism objects are updated with the
    refseq accessions and .add()ed to the passed :param:db_session.
    45 """

    organisms = ucscbrowser.get_org_list()
    accessions = get_accessions()

    50 for org in organisms:
        ot = org.title
        for gt, acc in accessions:
            if ot == gt:
                org.acc = acc
                db_session.add(org)
    55

    not_found = set(organisms) - \
        set(db_session.query(UCSCOrganism).all())

```

```

60     # try fuzzy-matching the title
    # of those organisms that were not found
    for org in not_found:
        ot = org.title
        best_ratio = 0
65         best_match = None
        for gt, acc in accessions:
            ratio = difflib.SequenceMatcher(None, ot, gt).ratio()
            if ratio > best_ratio:
                best_ratio = ratio
70                 best_match = acc
                best_match_t = gt

        if best_ratio > 0.8:
            if db_session.query(UCSCOrganism).get(best_match):
75                 log.debug(("NOT using '{match}' for '{org}'"
                             " despite match ratio of: {ratio}").format(
                                 match=best_match_t, org=ot, ratio=best_ratio))
            else:
                log.info(("using '{match}' for '{org}'"
                        " match ratio: {ratio}").format(
80                             match=best_match_t, org=ot, ratio=best_ratio))
                org.acc = best_match
                db_session.add(org)
        else:
85             log.warn(("'{org}' not found in NCBI 'genome' database"
                        " (best match ratio only {ratio}").format(
                            org=ot, ratio=best_ratio))

    # make sure that that regular expression in views.post() that translates
90    # the 'org_accession' from 'title (db/accession)', as generated in
    # rnaseqlyze.create.js, back to 'accession' doesn't fail
    for org in db_session.query(UCSCOrganism).all():
        if any(needle in heystack
95                for needle in '()'
                for heystack in (org.db, org.acc, org.title)):
            log.warn("Dropping organism with parenthesis"
                    " to avoid problems in parsing auto"
                    "completed form input in views.post()")
            db_session.expunge(org)
100
def get_accessions():

    data_file = resource_stream(__name__, prokaryotes_tsv)
    reader = csv.reader(data_file, delimiter='\t')
105    headings = reader.next()
    colnums = dict(zip(headings, map(headings.index, headings)))
    # -> { '#Organism/Name': 0, ..., 'Chromosomes/RefSeq': 7 }
    ret = []
    for cols in reader:
110        if cols[colnums['Chromosomes/RefSeq']] == '-':
            continue
        ret.append((cols[colnums['#Organism/Name']],
                    cols[colnums['Chromosomes/RefSeq']]))

```

```
return ret
```

Modul rnaseqlyze.s3

```

"""
Upload files to Amazon S* using the s3cmd tools

The access credentials must be configured in ~/.s3cfg .
5 The s3cmd creates this file interactively with the --configure option.
"""

#: The s3 bucket name in "S3Uri" format
base_uri = "s3://biocalc/"

10 import os

# import this to fix a circular import dependency problem in s3cmd ...
import S3.Exceptions

15 from S3.S3 import S3
from S3.Config import Config
from S3.S3Uri import S3Uri
from S3.SortedDict import SortedDict

20 # same "interface" like rnaseqlyze.galaxy
def upload(fileobj, filename):

    cfg = Config()

25     cfg.read_config_file(os.path.join(os.getenv("HOME"), ".s3cfg"))
    cfg.progress_meter = False
    cfg.acl_public = True

30     s3 = S3(cfg)

    headers = SortedDict(ignore_case = True)
    headers["x-amz-acl"] = "public-read"
    headers["x-amz-storage-class"] = "REDUCED_REDUNDANCY"

35     remote_uri = S3Uri(base_uri + filename)

    fileobj.seek(0,2) # seek to end
    size = fileobj.tell()
40     fileobj.seek(0) # seek to start

    response = s3.send_file_multipart(fileobj, headers, remote_uri, size)

    assert response['status'] == 200

45     return remote_uri.public_url()

```

Modul rnaseqlyze.transterm

```

"""
A module to run transterm_hp
"""

5 import os, subprocess
from subprocess import PIPE

def run(args, out=None, err=None):
    """
10    Run transterm_hp with the given arguments plus "-p expterm.dat"
    """
    def findit():
        for path in os.getenv("PATH").split(os.path.pathsep):
            for name in os.listdir(os.path.join(path, "../lib")):
15                if name == 'expterm.dat':
                    return os.path.join(path, "../lib", name)
    expterm_dat = findit()
    if not expterm_dat:
        raise Exception("'expterm.dat' not found")
    cmd = ('transterm', '-p', expterm_dat) + tuple(args)
20    proc = subprocess.Popen(cmd, stdout=out, stderr=err)
    proc.wait()
    if proc.returncode != 0:
        raise Exception(str(cmd) + " failed")
25
def tt2bed(tt_output, bed_file):
    for id, begin, strand, confidence in iterator(tt_output):
        # let color vary from 0 (black) to 100 (gray)
        rgb_color = ','.join((str(100 - int(confidence)),)*3)
30    print >> bed_file, '\t'.join((
        'chr', begin, end, 'TERM_' + id,
        str(confidence), strand, begin, end, rgb_color
    ))

35 def iterator(tt_output):
    for line in tt_output:
        if not line.startswith(" TERM"):
            continue
        TERM, id, begin, dash, end, \
40         strand, position, confidence, rest = line.split(None, 8)
        # switch begin & end on reverse strand
        if strand == '-':
            begin, end = end, begin
        yield id, begin, end, strand, int(confidence)

```

Modul rnaseqlyze.ucscbrowser

```

"""
Tools to deal with the UCSC genome browser at http://archaea.ucsc.edu/
"""
import logging
5 log = logging.getLogger(__name__)

from json import load

```

```

from urllib2 import urlopen
from urlparse import urljoin
10 from StringIO import StringIO
from shutil import copyfileobj
from os import listdir, makedirs
from os.path import join, dirname, isdir

15 from lxml.html import parse
from lxml.etree import dump

import rnaseqlyze
from rnaseqlyze.core import security
20 # delay import because of a
# circular import dependency ...
# from rnaseqlyze.core.entities import UCSCOrganism

cart_reset_url = "http://archaea.ucsc.edu/cgi-bin/cartReset"
25 custom_track_url = "http://archaea.ucsc.edu/cgi-bin/hgTracks"
custom_track_params = "?db={org_db}&hgt.customText={track_url}"

class BigDataTrack(str):
    """
30     A UCSC "Big Data Track"

    You should pass a 'name' and a 'url'
    keyword argument to the constructor.
    """

35     template = 'track type="{type}" name="{name}" bigDataUrl="{url}"'

    __new__ = lambda cls, **kwargs: cls.template.format(type=cls.type, **kwargs)

40 class BAMTrack(BigDataTrack): type = "bam"
class BigWigTrack(BigDataTrack): type = "bigWig"
class BigBedTrack(BigDataTrack): type = "bigBed"

# FIXME:
45 #     The org_list_default_dir = dirname(__file__)
#     hack will not work if the distribution is installed
#     as a zipped .egg. pkg_resources.resource_stream or
#     pkg_resources.resource_string should be used instead.
org_list_base_url = "http://archaea.ucsc.edu/wp-content/data/"
50 org_list_default_dir = join(dirname(__file__), "ucscbrowser-data")
json_links_file_name = "ucsc-wp-data.html"

def get_org_list():
    global UCSCOrganism
55     from rnaseqlyze.core.entities import UCSCOrganism

    global org_list_cache_dir
    if not hasattr(rnaseqlyze, 'ucsc_org_list_cache_dir'):
        raise Exception("rnaseqlyze.configure(workdir) "
60                        "must be called before calling this function")
    org_list_cache_dir = rnaseqlyze.ucsc_org_list_cache_dir

```

```

        if not isdir(org_list_cache_dir):
            makedirs(org_list_cache_dir)
65
        orgs = []
        for org in get_organisms(get_json_files()):
            for existing in orgs:
                if existing.title == org.title:
70                 log.warn("'{}' already present (db: {}/{})" % \
                           (org.title, org.db, existing.db))
                    break
                else:
                    orgs.append(org)
75
        return orgs

def get_json_files():

    json_links_file = None
80    json_files = None

    for get_json_links_file in (get_json_links_file_web,
                                get_json_links_file_cache,
                                get_json_links_file_default,):
85        try:
            log.debug("trying {}" % get_json_links_file.func_name)
            json_links_file = get_json_links_file()
        except Exception, e:
            log.warn("{} failed: {}" % (get_json_links_file.func_name, e))
90            continue

    for get_json_files in (get_get_json_files_web(json_links_file),
                            get_json_files_cache,
                            get_json_files_default,):
95        try:
            log.debug("trying {}" % get_json_files.func_name)
            return get_json_files()
        except Exception, e:
100        log.warn("{} failed: {}" % (get_json_files.func_name, e))

    raise Exception("Couldn't get json organism lists")

# getting the links file
105
def get_json_links_file_web():
    json_links_file = StringIO()
    copyfileobj(urlopen(org_list_base_url), json_links_file)
    json_links_file.seek(0)
110    return json_links_file

def get_json_links_file_cache():
    return open(join(org_list_cache_dir, json_links_file_name))

115 def get_json_links_file_default():
    return open(join(org_list_default_dir, json_links_file_name))

```

```

# getting json files
120
def get_get_json_files_web(json_links_file):

    def get_json_files_web():
        for e in parse(json_links_file).getroot().iter("a"):
125             link = e.attrib['href']
            if link.endswith(".json"):
                security.check_valid_filename(link)
                # FIXME: The json files should also be returned as StringIO
                #         buffers only and the cache files shouldn't be
130                 #         overwritten until it is certain that the newly
                #         downloaded files contain the expected data
                json_file = open(join(org_list_cache_dir, link), "w+")
                copyfileobj(urlopen(urljoin(
                    org_list_base_url, link)), json_file)
135                 json_file.seek(0)
                yield json_file

    try:
        json_links_file.fileno()
140         # json_links_file was defaults or cached
    except:
        # json_links_file was a memory buffer - save it because
        # if this code is reached, it means there was no error,
        # in the code above, so the buffer likely contains good links
145         json_links_file.seek(0)
        copyfileobj(json_links_file, open(join(
            org_list_cache_dir, json_links_file_name), "w"))

    return get_json_files_web

150
def get_json_files_cache():
    for json in listdir(org_list_cache_dir):
        if json.endswith(".json"):
            yield open(join(org_list_cache_dir, json))
155
def get_json_files_default():
    for json in listdir(org_list_default_dir):
        if json.endswith(".json"):
            yield open(join(org_list_default_dir, json))
160

# creating UCSCOrganism objects from json files

def get_organisms(json_files):
165     for json_file in json_files:
        for object in load(json_file):
            for child in object['children']:
                for grandchild in child['children']:
                    if grandchild['attr']['rel'] == 'genome':
170                         yield UCSCOrganism(db=grandchild['attr']['id'],
                                                title=grandchild['data']['title'])

```

3.1.2 Package rnaseqlyze.core

Modul rnaseqlyze.core

```
"""
Core functionality
"""
```

Modul rnaseqlyze.core.analysis

```
"""
Property getters and methods for Analysis instances
"""
```

```
5  import logging
    log = logging.getLogger(__name__)

    import os
    from os.path import join, exists
10  import datetime
    from urllib import quote

    from sqlalchemy import ForeignKey
    from sqlalchemy import Table, Column
15  from sqlalchemy import Boolean, Integer, String, Text, DateTime
    from sqlalchemy.orm import relationship, backref, validates
    from sqlalchemy.orm.properties import RelationshipProperty
    from sqlalchemy.ext.declarative import declared_attr, declarative_base

20  import rnaseqlyze
    from rnaseqlyze import galaxy
    from rnaseqlyze import ucscbrowser
    from rnaseqlyze.core import security

25  class Methods(object):
        """
        Here the various analysis configurations are handled
        as transparently as possible. The properties should be
        seasy to deal with so the worker.core code doesn't get too hairy.

30        .. note::

            Weather the input is an SRR identifier or a sra/fastq file is
            distinguished by checking "self.inputfile_name == None" in at least

35            - the Worker
            - the analysis.pt template
            - in this file

        .. note::

40            Weather the organism input is a NCBI RefSeq accession or a genbank file
```



```

        is distinguished by checking "self.genbankfile_name == None" in at least
        - the Worker
        - the analysis.pt template
45     - in this file
    """

    def __init__(self, **kwargs):
        super(Methods, self).__init__(**kwargs)
50     self.creation_date = datetime.datetime.utcnow()

    def create_data_dir(self):
        if not os.path.isdir(self.data_dir):
            os.makedirs(self.data_dir)
55

    # org_db and hg_url (which depends upon org_db) are not set
    # as a db attribute, so old analyses where the organism was not
    # known at creation time automatically get the right url set if the
    # organism later on becomes available in the UCSC Browser
60

    def get_hg_url(self, org_db):
        if not self.galaxy_hg_text:
            return
        hg_url = ucscbrowser.custom_track_url + \
65         ucscbrowser.custom_track_params.format(
            org_db=org_db, track_url=quote(self.hg_url))
        return hg_url

    def get_galaxy_id(self, name):
70     for ds in self.galaxy_datasets:
        if ds.name == name:
            return ds

class Properties(object):
75

    """
    .. note::

        - `input` means `short reads data`
80     - `genbank` means `"genome" database nucleotide sequence`
    """

    # data uploaded or id specified ?
    # -----

85     @property
    def inputfile_uploaded(self):
        return self._inputfile_name and True

    @property
90     def genbankfile_uploaded(self):
        return self._genbankfile_name and True

    # directories
95     # -----

```

```

@property
def data_dir(self):
    return join(rnaseqlyze.analyses_path, str(self.id))
100

@property
def input_data_dir(self):
    if self.inputfile_uploaded:
        return self.data_dir
105    else:
        return self.rnaseq_run.data_dir

@property
def genbank_data_dir(self):
110    if self.genbankfile_uploaded:
        return self.data_dir
    else:
        return join(rnaseqlyze.shared_data_path, self.org_accession)

115 # short reads files
# -----

@property
def inputfile_name(self):
120    return self._inputfile_name \
        or self.rnaseq_run and self.rnaseq_run.srr + ".sra"

@property_name.setter
def inputfile_name(self, value):
125    self._inputfile_name = value

@property
def inputfile_path(self):
    return join(self.input_data_dir, self.inputfile_name)
130

@property
def inputfile_base_name(self):
    return self.inputfile_name.rsplit(".", 1)[0]

135 @property
def inputfile_fq_name(self):
    return self.inputfile_base_name + ".fastq"

@property
140 def inputfile_fq_path(self):
    return join(self.input_data_dir, self.inputfile_fq_name)

@property
def inputfile_header(self):
145    if not exists(self.inputfile_fq_path):
        return
    fq_file = open(self.inputfile_fq_path)
    lines = [fq_file.readline() for i in range(4)]
    log.info("Header: %s" % lines[0])
150    fq_file.close()

```

```

        return "".join(lines)

# organism files
# -----

155     @property
    def genbankfile_name(self):
        return self._genbankfile_name \
            or self.org_accession and self.org_accession + ".gb"

160     @genbankfile_name.setter
    def genbankfile_name(self, value):
        self._genbankfile_name = value

165     @property
    def genbankfile_path(self):
        return join(self.genbank_data_dir, self.genbankfile_name)

    @property
170     def genbankfile_base_name(self):
        return self.genbankfile_name.rsplit(".", 1)[0]

    @property
    def genbankfile_fa_name(self):
175         return self.genbankfile_base_name + ".fa"

    @property
    def genbankfile_fa_path(self):
        return join(self.genbank_data_dir, self.genbankfile_fa_name)

180     @property
    def xgenbankfile_name(self):
        return self.genbankfile_base_name + ".augmented.gb"

185     @property
    def xgenbankfile_path(self):
        return join(self.data_dir, self.xgenbankfile_name)

# magic galaxy_xxx attributes
190 # -----

    galaxy_stuff = "hg_text bam coverage hp_terms pr_operons".split()

    for x in galaxy_stuff: exec """if True: # just to enable indentation ...
195         @declared_attr
        def galaxy_%s(self):
            return relationship("GalaxyDataset",
                               uselist=False, primaryjoin="%s")""" % (x,

200                                "and_(GalaxyDataset.type == '%s', "
                                "Analysis.id == GalaxyDataset.analysis_id)" % x)

    del x
    @validates*(("galaxy_" + x for x in galaxy_stuff))
    def _set_galaxy_(self, attr, dataset):

```

```

205         dataset.type=attr[7:]
           return dataset

# other things
# -----

210     @property
       def hg_url(self):
           if not self.galaxy_hg_text:
               return
215           return "https://" + galaxy.hostname \
               + galaxy.dataset_display_url_template \
               .format(dataset=self.galaxy_hg_text.id)

       @property
220     def data_dir_state(self):
           return hash(tuple((x,tuple(y),tuple(z))
                           for x, y, z in os.walk(self.data_dir)))

       @property
225     def stage_logs_state(self):
           return hash(tuple(log.text for log in self.stage_logs))

class Validators(object):
    @validates('org_accession')
230     def validate_org_accession(self, attr, acc):
           security.check_valid_filename(acc)
           return acc.upper()

    @validates('strandspecific', 'pairedend')
235     def validate_boolean(self, attr, val):
           return val and True or False

    @validates('inputfile_name', 'genbankfile_name')
       def validate_x_file_name(self, attr, name):
240           if '\\\\' in name:
               name = name.rsplit('\\\\', 1)[1]
               security.check_valid_filename(name)
               if name.find('.') < 0:
                   raise Exception("Please make sure your input file has a"
245                               " (meaningful) extension, like .fastq or .sra")
               return name

class Mixins(Methods, Properties, Validators):
    pass

```

Modul rnaseqlyze.core.entities

"""

SQLAlchemy Database Entities

A nice tutorial showing how everything works is `here

5 <<http://docs.sqlalchemy.org/en/latest/orm/tutorial.html>>`_.

```

"""

from rnaseqlyze.core.orm import *

10 class Analysis(AnalysisMixins, Entity):

    # The order of superclasses matters!
    # AnalysisMethods.__init__ calls Entity.__init__

15 """
    The central entity.
    Represents an analysis by a researcher.
    The whole rnaseqlyze project basically revolves around this entity.
    """

20 id = Column(Integer, primary_key=True)

    org_gid = Column(Integer) # Organisms Genebank/Entrez gid
    org_accession = Column(String) # Organisms Genebank accession number

25 _inputfile_name = Column("inputfile_name", String)
    inputfile_type = Column(String)
    _genbankfile_name = Column("genbankfile_name", String)

30 strandspecific = Column(Boolean)
    pairedend = Column(Boolean)
    pairedrlen = Column(Integer)

    owner = relationship("User", backref=backref("analyses"))
35 owner_name = Column(String, ForeignKey('user.name'))

    creation_date = Column(DateTime)
    started = Column(Boolean)
    finished = Column(Boolean)
40 stage = Column(String)
    error = Column(String)

    rnaseq_run = relationship("RNASeqRun", backref=backref("analyses"))
    rnaseq_run_srr = Column(String, ForeignKey('rnaseqrun.srr'))

45 # ft_predictions = `backref` from FeaturePredictions
    # hg_tracks = `backref` from HgTrack
    # galaxy_datasets = `backref` from GalaxyDataset

50 class UploadSession(Entity):
    """
    Is created when somebody uploads a file
    """

    id = Column(Integer, primary_key=True)
55 analysis_id = Column(Integer, ForeignKey(Analysis.id))
    analysis = relationship(Analysis, uselist=False)

class User(Entity):
    """

```

```

60     Constitutes a user of this service
        """
        name          = Column(String, primary_key=True)
        # analyses      = `backref` from Analysis

65     def __init__(self, name):
        self.name = name

        # SRA analogons

70     class RNASeqStudy(Entity): # stub
        """
        Constitutes an SRA "SRP" == SRA Study
        """
        srp            = Column(String, primary_key=True)
        # analyses      = `backref` from Analysis
75        # experiments  = `backref` from RNASeqExperiment

        class RNASeqExperiment(Entity): # stub
        """
80        Constitutes an SRA "SRX" == SRA Experiment
        """
        srx            = Column(String, primary_key=True)
        srp_srp        = Column(Integer, ForeignKey(RNASeqStudy.srp))
        srp            = relationship(RNASeqStudy, backref=backref("experiments"))
85        # runs         = `backref` from RNASeqRun

        class RNASeqRun(RNASeqRunMixins, Entity):
        """
        Constitutes an SRA "SRR" == SRA Run
        """
90        srr            = Column(String, primary_key=True)
        srx_srx         = Column(Integer, ForeignKey('rnaseqexperiment.srx'))
        srx             = relationship(RNASeqExperiment, backref=backref("runs"))

95        class UCSCOrganism(Entity):
        """
        Holds information about the mapping of UCSC browser "db" names to
        "gene id 'title'"s, and RefSeq Accessions.
        """
100        acc           = Column(String, primary_key=True)
        db              = Column(String, unique=True)
        title           = Column(String, unique=True)

        class GalaxyDataset(Entity):
105        """
        Holds a mapping from an analysis to a galaxy dataset id
        """
        id              = Column(String, primary_key=True)
        analysis_id     = Column(Integer, ForeignKey(Analysis.id), primary_key=True)
110        analysis      = relationship(Analysis, backref=backref("galaxy_datasets"))
        type            = Column(String)
        name            = Column(String)

```

```

class StageLog(Entity):
115     """
        Holds the log output of one processing stage
        """
        # the primary key could be stage/analysis_id
        # but using an id automatically adds ordering
120     # which comes handy, because how to order the stages otherwise ?
        id = Column(Integer, primary_key=True)
        stage = Column(String)
        analysis_id = Column(Integer, ForeignKey(Analysis.id))
        analysis = relationship(Analysis, backref=backref("stage_logs"))
125     text = Column(Text)

```

Modul rnaseqlyze.core.orm

```

"""
This module declares and imports everything needed to
define the database entity classes in :mod:`.entities`.
"""

5
from sqlalchemy import (
    ForeignKey,
    Table, Column,
    Boolean, Integer,
10    String, Text, DateTime
)
from sqlalchemy.orm import relationship, backref
from sqlalchemy.ext.declarative import declared_attr

15 from rnaseqlyze.core.analysis import Mixins as AnalysisMixins
from rnaseqlyze.core.srr import Mixins as RNASeqRunMixins

class _Entity(object):
20     @declared_attr
    def __tablename__(cls):
        return cls.__name__.lower()

    def __setattr__(self, name, value):
25
        # raise an exception when setting
        # attributes that are not db columns
        if not (name.startswith('_') or hasattr(type(self), name)):
            raise Exception("%s' is not a declared attribute" % name)
30
        super(_Entity, self).__setattr__(name, value)

from sqlalchemy.ext.declarative import declarative_base
Entity = declarative_base(cls=_Entity)
35 del declarative_base

```

Modul rnaseqlyze.core.security

```

"""
A collection of security related functions.

In case a check fails, an exception is raised, otherwise None is returned.
"""
5

def check_valid_filename(name):
    """
    Assert that the passed name doesn't contain
    any "funny" characters (e.g. ../../../../sensitive.txt)
    """
    10

    max_len = 128
    assert len(name) < max_len, "Filename too long"

    15
    import string
    assert set(name) < set(string.digits + string.letters + '._'), \
        "Only digits, letters, point and underscore allowed in filenames"

Modul rnaseqlyze.core.service

import logging
log = logging.getLogger(__name__)

import os
5 import urllib2

import rnaseqlyze
from rnaseqlyze.core import security
from rnaseqlyze.core.entities import Analysis, User, RNASeqRun, UploadSession
10 def get_upload_session(db_session):
    sess = UploadSession()
    db_session.add(sess)
    db_session.flush()
    return sess

    15
def get_uploadfile(db_session, session, name, type):
    # This doesn't look right, but it works. The database needs to
    # be locked here to make sure that the first upload request that
    # comes in creates the analysis and the second uses the same analysis.
    20 # We need to lock the whole database and this seemingly useless statement
    # does just that. With SQLite. I have been asking on irc #sqlalchemy about
    # how to do it the right way, but I didn't get any useful reply. I have
    # checked the SQLAlchemy as well as the SQLite docs and tried various things
    # like DBSession.execute("BEGIN") and such things - nothing seems to work
    25 # - this is the only solution I have found.
    #
    # EDT: it could be as simple as increasing the sqlalchemy debug level, check
    # what sql statements are executed and then DBSession.execute() those
    #
    30 session.analysis = session.analysis
    #
    if not session.analysis:
        session.analysis = Analysis()

```



```

    db_session.add(session.analysis) # needed ?
35    db_session.flush() # sets analysis.id
    session.analysis.create_data_dir()

    assert type in ('inputfile', 'genbankfile')

40    typename = type + '_name'

    # inputfile_name -> Short Reads in SRA or FASTQ format
    # genabnkfile_name -> Organism genbank file
    #=if session.analysis.inputfile_name:
45    if getattr(session.analysis, type + '_uploaded'):
        # you land here if a user uploads
        # more than one file per type
        # this is not intended, BUT
        # these are the interwebs!
50        pass # FIXE: remove old

    #=session.analysis.inputfile_name = name
    setattr(session.analysis, typename, name)

55    log.debug("creating upload file '%s' for analysis #%d" % (
        name, session.analysis.id))

    # this would be the place to throw in a wrapper
    # to track upload progress the old way, i.e.
60    # with server callbacks...

    #inputfile_path is a @property
    return open(getattr(session.analysis, type + '_path'), "w+b")

65 def get_analysis(db_session, attributes):

    # owner handling
    if 'owner' not in attributes:
        owner = db_session.query(User).get("anonymous")
70        if not owner:
            owner = User("anonymous")
            db_session.add(owner)
            attributes['owner'] = owner

75    # srr handling
    rnaseq_run = None
    if 'rnaseq_run' in attributes \
    and 'inputfile_name' not in attributes:
        log.debug("rnaseq_run: %s" % attributes['rnaseq_run'])
80        rnaseq_run = db_session.query(RNASEqRun).get(attributes['rnaseq_run'])
        if rnaseq_run:
            attributes['rnaseq_run'] = rnaseq_run
        else:
            try:
85                log.debug("creating new RNASEqRun")
                rnaseq_run = RNASEqRun(srr=attributes['rnaseq_run'])
                attributes['rnaseq_run'] = rnaseq_run

```

```

        rnaseq_run.create_directories()
        db_session.add(rnaseq_run)
90     except Exception, e:
        # The RNaseqRun constructor checks the SRRnnnnnn argument
        # and raises an exception unless it passes the checks
        # e.g. if field was left blank/at default value
        # TODO: decide/document what to do
95     log.debug("failed: %r" % e)
        del attributes['rnaseq_run']

upload_session = db_session.query(UploadSession) \
    .get(attributes['upload_session'])
100 del attributes['upload_session']
if not upload_session:
    raise Exception('this session has expired -'
        ' reload the "New Analysis" page to start a new one')

105 # the analysis exist already if the user uploaded something
if upload_session.analysis:
    analysis = upload_session.analysis
    for attr, value in attributes.items():
        setattr(analysis, attr, value)
110 else:
    # create db object
    log.debug("creating new analysis: %s" % attributes)
    analysis = Analysis(**attributes)
115 db_session.add(analysis)
    db_session.flush() # sets analysis.id
    analysis.create_data_dir()

# allow no more uploads to this analysis
120 db_session.delete(upload_session)

# if no input file has been uploaded
if not analysis.inputfile_name:
    # an SRR identifier is needed
125 if rnaseq_run:
        analysis.rnaseq_run = rnaseq_run
    else:
        raise Exception("Please upload an input file or specify an SRR id")

130 return analysis

def start_analysis(analysis):
    url = "http://127.0.0.1:6543/analyses/%d"
    rq = RNASWorkerSTARTRequest(url % analysis.id)
135 opener = urllib2.build_opener(HTTPRNASWorkerHandler())
    rsp = opener.open(rq)
    body = rsp.read()
    rsp.close()

140 class RNASWorkerSTARTRequest(urllib2.Request):
    def get_method(self):

```

```

        return 'START'

class HTTRNASWorkerHandler(urllib2.HTTPHandler):
145     def http_error(self, req, fp, code, msg, hdrs):
        raise WorkerException(fp.read())
        http_error_400 = http_error
        http_error_500 = http_error

150 class WorkerException(Exception):
    def __init__(self, exc_body):
        self.exc_body = exc_body
    def __repr__(self):
        return "WorkerException()"
155    def __str__(self):
        return self.exc_body

```

Modul rnaseqlyze.core.sra

Modul rnaseqlyze.core.srr

```

"""
Sequence Run Archive interaction
"""

5  import logging
    log = logging.getLogger(__name__)

    import os
    from os import path
10  from time import time
    from urllib2 import urlopen
    from urlparse import urlparse
    from httplib import HTTPConnection
    from socket import timeout

15  from sqlalchemy.orm import validates

    import rnaseqlyze

20  url_template = "http://ftp-private.ncbi.nlm.nih.gov" \
        "/sra/sra-instant/reads/ByRun/sra/{srr:.3}/{srr:.6}/{srr}/{srr}.sra"
    # e.g.  "/sra/sra-instant/reads/ByRun/sra/SRR/SRR000/SRR000001/SRR000001.sra"

    class Methods(object):
25
        def download(self):
            srr_url = url_template.format(srr=self.srr)
            log.info("fetching %s" % srr_url)
            url_parts = urlparse(srr_url)
30
            resp = None
            max_tries = 3

```

```

for tries_left in reversed(range(max_tries)):
35     try:
        conn = HTTPConnection(url_parts.netloc, strict=True, timeout=60)

        msg = "connecting to server"
        log.debug(msg)
40         conn.connect()

        msg = "sending GET request"
        log.debug(msg)
        conn.request("GET", url_parts.path)

45         msg = "waiting for response from server"
        log.debug(msg)
        resp = conn.getresponse()

50         break
    except timeout:
        log.warn("timeout " + msg)
        if tries_left > 0:
            log.info("trying %d more time%s" %
55                     (tries_left, tries_left > 1 and 's' or ''))
        else:
            log.error("tried %d times - giving up", max_tries)
            raise

60     # Impossible really, but...
    assert resp != None

    if resp.status != 200:
        problem = "Bad response from server: %d - %s" % (
65                     resp.status, resp.msg.status)

        log.error(problem)
        raise Exception(problem)

    try:
70         local = open(self.sra_path, "w")
        total = resp.length
        read = 0
        then = time()
        log.info("transferring %d kb data..." % (total / 1024
75                     if total else -1))

        while True:
            buf = resp.read(16*1024)
            read += len(buf)
            now = time()
            if then < now - 15:
                then = now
                log.info("%d kb left" % (((total or 0) - read) / 1024))
            if not buf:
                break
80             local.write(buf)
        except Exception, e:
            log.error("Error downloading SRR: %r" % e)

```

```

        os.unlink(self.sra_path)
        raise
90    finally:
        # note:
        #   in case of an error, unlinking wil precede closing
        #   -- no problem on unix
        local.close()

95    log.debug("Success!")

class Properties(object):
    @property
100    def data_dir(self):
        return path.join(rnaseqlyze.shared_data_path, self.srr)

    @property
    def sra_path(self):
105    return path.join(self.data_dir, self.sra_name)

    @property
    def sra_name(self):
        return self.srr + ".sra"
110

    def create_directories(self):
        if not os.path.isdir(self.data_dir):
            os.makedirs(self.data_dir)

115 class Validators(object):
    @validates('srr')
    def check_srr(self, key, srr):
        import string
        assert len(srr) == 9
        assert srr[:3] == 'SRR'
120    assert set(srr[3:]) < set(string.digits)
        # ... what a powerful language python is! :-)
        # http://docs.python.org/library/stdtypes.html#set
        # http://docs.python.org/library/string.html#string-constants
125    return srr.upper()

class Mixins(Methods, Properties, Validators):
    pass

```

3.1.3 Package rnaseqlyze.cli

Modul rnaseqlyze.cli

```

"""
Programs runnable from the command line.

For each module contained in this package, a wrapper script
5  called `rnas-<module name>` will be installed in `<prefix>/bin`.
"""

```

```
from .. import project_name
project_name += "-cli"
```

Modul rnaseqlyze.cli.apidoc

```
"""
RNA-Seqlyze ApiDoc Generator

Usage:
5   rnas-apidoc -h|--help
   rnas-apidoc [-s|--source] <path> ...

Generates one <package>.rst sphinx apidoc source file,
in the current directory, for each package found in <path>.
10

Options:
   -s --source      Use `literalinclude` in addition to `automodule`.
                    When using this option, the generated output will be
                    optimized for processing with the sphinx latexpdf module that
15   generates a pdf document. Even without this option, when
                    using the html output module, the modules source code will
                    still be available in the generated Website, but not on the
                    same pages as the rest of the modules documentation
                    (controlled by the "html_show_sourcelink" option in
20   apidoc/conf.py).

"""
import os, sys
from pkgutil import walk_packages
25

def main():
    import docopt
    opts = docopt.docopt(__doc__)

30   global pkg_tpl
   global mod_tpl
   if opts['--source']:
       pkg_tpl, mod_tpl = pkg_src_tpl, mod_src_tpl

35   #: implicit args to write():
   #: pkg.outfile, pkgpath, name, filename
   def write(tpl, **kwargs):
       pkg.outfile.write(tpl.format(
           name=name, path=pkgpath + os.sep + filename,
40   equals="=" * len(name), dashes="-" * len(name), **kwargs))

   packages = {}
   Package = type('', (), {})

45   # requirement/assumption:
   # parent packages will come before their children
   for loader, name, is_pkg in walk_packages(opts['<path>']):
```

```

pkgname = name.rsplit('.', 1)[0]
50 pkgpath = os.path.relpath(loader.path, ".")

if is_pkg:
    # note: 'pkgname' is actually the
    #       _parent_ package name in this case
55
    # associate non-root-packages with their parents
    if '.' in name:
        packages[pkgname].subpackages.append(name)

60
    # create & init a 'Package' object,
    # open <fully-qualified-package-name>.rst
    # and set filename to <package-name>/__init__.py
    pkg = Package()
    pkg.subpackages = []
65
    print "creating %s.rst" % name
    pkg.outfile = open(name + '.rst', 'w')
    filename = name.split('.')[-1] + os.sep + '__init__.py'

    # add the package to the list
70
    # and write the packages .rst file heading
    packages[name] = pkg
    write(pkg_tpl)

else:
75
    # skip modules that are not part of any package, like setup.py
    if pkgname not in packages:
        continue

    # find the containing package and set filename to <module>.py
80
    pkg = packages[pkgname]
    filename = name[len(pkgname)+1:] + '.py'

    # append the doc entry for this module to the package .rst file
    write(mod_tpl)
85

if not opts['--source']:
    for pkg in packages.values():
        if pkg.subpackages:
            write(sub_pkg_tpl, names="\n\t".join(pkg.subpackages))
90

pkg_tpl = """\
:mod: `{name}`\
{equals}=====

95 .. automodule:: {name}

"""

pkg_src_tpl = """\
100 :mod: `{name}`\
{equals}=====

```

```

:mod:~{name}~
{dashes}-----
105
.. automodule:: {name}

Source Code:

110 .. literalinclude:: {path}

"""

mod_tpl = """\
:mod:~{name}~
115 {dashes}-----

.. automodule:: {name}

120 """

mod_src_tpl = """\
:mod:~{name}~
{dashes}-----
125
.. automodule:: {name}

Source Code:

130 .. literalinclude:: {path}

"""

sub_pkg_tpl = """\
135 Subpackages
-----

.. toctree::
    :titlesonly:

140
    {names}

"""

```

Modul rnaseqlyze.cli.galaxy_upload

```

"""
RNA-Seqlyze Galaxy-Upload

Usage:
5   rnas-galaxy-upload <local_file>
"""

import sys, os
from rnaseqlyze import galaxy

10 def main():

```



```

    if len(sys.argv) < 2 or sys.argv[1] in ('-h', '--help'):
        print __doc__
        return
15     print galaxy.upload(open(sys.argv[1]), os.path.basename(sys.argv[1]))

```

Modul rnaseqlyze.cli.gb2fasta

```

"""
RNA-Seqlyze gb2fasta

Convert a genbank file to fasta format
5
Usage:
    rnas-gb2fasta <input.gb> <output.fa>

If <input.gb> is '-', use 'sys.stdin', if <output.fa> is '-', use 'sys.stdout'.
10 """
import sys
import Bio.SeqIO

def main():
15
    if len(sys.argv) < 2 or sys.argv[1] in ('-h', '--help'):
        print __doc__
        return

    inputfile = sys.argv[1] == '-' and sys.stdin or open(sys.argv[1])
    outputfile = sys.argv[2] == '-' and sys.stdout or open(sys.argv[2], "w")
    Bio.SeqIO.write(Bio.SeqIO.parse(inputfile, "genbank"), outputfile, "fasta")
20

```

Modul rnaseqlyze.cli.gb2ptt

```

"""
RNA-Seqlyze gb2ptt

Convert a genbank file to ptt (protein table) format
5
Usage:
    rnas-gb2ptt <input.gb> <output.ptt>

If <input.gb> is '-', use 'sys.stdin', if <output.ptt> is '-', use 'sys.stdout'.
10 """
import sys, logging
from rnaseqlyze.gb2ptt import gb2ptt

def main():
15
    if len(sys.argv) < 2 or sys.argv[1] in ('-h', '--help'):
        print __doc__
        return

```

```

20     inputfile = sys.argv[1] == '-' and sys.stdin or open(sys.argv[1])
       outputfile = sys.argv[2] == '-' and sys.stdout or open(sys.argv[2], "w")

       login.basicConfig(level=logging.NOTSET) # logs to stderr

25     gb2ptt(inputfile, outputfile)

```

Modul rnaseqlyze.cli.init

```

"""
RNA-Seqlyze Init

(Re-)initialize an rnaseqlyze 'workdir'.

5  Usage:
    rnas-init <workdir>
    rnas-init --recreatedb <workdir>
    rnas-init --development <workdir>
10   rnas-init -h|--help

Options:
    --recreatedb
                               Remove and re-initialize the database if it exists.

15   --development
                               Use the development versions of the config file templates.

Arguments:
20   <workdir>
                               The filesystem path to the directory to be initialized.
                               If the directory already exists, by default, existing
                               files inside that directory are not overwritten.

25   .. important::
                               The `WORKDIR` variable in the "/etc/init.d/rnaseqlyze.sh"
                               worker daemon startup script and the `workdir` variable
                               in the "/var/www/./rna-seqlyze.wsgi" script must both
                               be set to the directory specified here!

30   Documentation:

       The 'workdir' holds

35       - configuration files      (*.ini)
       - the application database  (`rnaseqlyze.db`)
       - log files                  (*.log)
       - shared data                (`shared_data/`)
       - individual analysis data  (`analyses/`)

40   The rnas-init command

       - creates the <workdir> if it does not already exist
       - copies default configuration files 'rnaseqlyze.ini', 'web.ini'

```

```

45         and 'worker.ini' into the <workdir> if they do not already exist.
        - initializes the database that is configured in the 'rnaseqlyze.ini'
          config file if it doesn't already exist and --recreatedb is not given.

    The database to be initialized is configured with "db_url =" in the
50    "[rnaseqlyze]" section in 'rnaseqlyze.ini'. It is expected to be an sqlite
    database. If the command creates the sqlite database file, it changes it's
    unix access mode to (octal) 0664 and the group membership is changed to
    <group>. <group> can be configured in 'rnaseqlyze.ini'. If the command
    creates the <workdir>, it changes it's unix access mode to (octal) 0775 and
55    the group membership is also changed to <group>. The command changes the
    unix access mode and group membership of all .log files inside the workdir
    to (octal) 0664 and <group>.
    """

60    import logging
    log = logging.getLogger(__name__)

    import os, sys, grp, shutil

65    import pkg_resources
    from sqlalchemy import create_engine
    from sqlalchemy.orm import sessionmaker

    import rnaseqlyze
70    import rnaseqlyze.web
    import rnaseqlyze.worker
    from rnaseqlyze.core.entities import Entity

    Session = sessionmaker()

75    def main():

        import docopt
        opts = docopt.docopt(__doc__)

80        workdir = os.path.abspath(opts['<workdir>'])

        # create the workdir if it does not exist
        wd_created = False
85        if not os.path.isdir(workdir):
            if os.path.exists(workdir):
                log.error("not a directory: '%s'" % workdir)
                sys.exit(1)
            log.info("creating workdir '%s'" % workdir)
90            os.makedirs(workdir)
            wd_created = True

        # create each config file that does not exist
        for pkg in rnaseqlyze, rnaseqlyze.web, rnaseqlyze.worker:
95            # determine the destination file name
            conf_name = pkg.__name__.split('.')[1] + ".ini"
            conf_path = os.path.join(workdir, conf_name)

```

```

100         if os.path.exists(conf_path):
            continue

        # determine the source file name
        if pkg.__name__ == "rnaseqlyze":
            # for the core package there is currently
            # only one config file template
105             ini = 'rnaseqlyze.ini'
        else:
            # for the non-core packages, take the desired version
            ini = opts['--development'] and "development.ini" or "production.ini"
110             # get the file as a resource stream, which works even
            # if the distribution is installed as a zipped .egg
            req = pkg_resources.Requirement.parse(pkg.project_name)
            res = pkg_resources.resource_stream(req, ini)
            log.info("creating config file '%s'" % conf_name)
115             shutil.copyfileobj(res, open(conf_path, "w"))

        # init rnaseqlyze configuration -- creates all .log files
        rnaseqlyze.configure(workdir)

120     # set proper permissions on the log files
    for name in os.listdir(workdir):
        if name.endswith('.log'):
            path = os.path.join(workdir, name)
            log.info("adjusting permissions on '%s'" % name)
125             os.chmod(path, 0664)
            os.chown(path, -1, grp.getgrnam(rnaseqlyze.group).gr_gid)

    # delayed because 'rnaseqlyze.group' was
    # not known before calling rnaseqlyze.configure() above
130    if wd_created:
        log.info("adjusting permissions on '%s'" % workdir)
        # change permission bits
        os.chmod(workdir, 0775)
        # change group membership
135         os.chown(workdir, -1, grp.getgrnam(rnaseqlyze.group).gr_gid)

    # get the database file path
    db_path = rnaseqlyze.db_url.split(":", 1)[1]

140    # remove the database file
    # if it exists and --recreatedb is given
    if os.path.exists(db_path) and opts['--recreatedb']:
        log.info("removing existing database file '%s'" %
145                    db_path.split('/')[-1])
        os.unlink(db_path)

    # create the database if it doesn't exist
    if not os.path.exists(db_path):

150         log.info("recreating database '%s'" % rnaseqlyze.db_url)

        # create sqlalchemy db engine

```

```

engine = create_engine(rnaseqlyze.db_url)

155     # create the file and initialize the schema
    with engine.begin() as conn:
        Entity.metadata.create_all(conn)

    log.info("adjusting permissions on database file")

160     # change permission bits
    os.chmod(db_path, 0664)
    # change group membership
    os.chown(db_path, -1, grp.getgrnam(rnaseqlyze.group).gr_gid)

165     log.info("initializing organism cache")

    # initialize UCSC Browser list of organisms
    from rnaseqlyze import org_cache
170     with engine.begin() as conn:
        session = Session(bind=conn)
        org_cache.refresh(session)
        session.commit()

175     log.info("workdir initialized")

```

Modul rnaseqlyze.cli.transterm

```

"""
RNA-Seqlyze transterm

Calls the transterm program
5 with an additional "-p <path to>/expterm.dat" argument.

Usage:
    rnas-transterm [--] <transterm arguments> ...
    rnas-transterm -h|--help
10 """
import sys
from rnaseqlyze.transterm import run

def main():
15     if len(sys.argv) > 1 and sys.argv[1] == '--':
        sys.argv.pop(1)
    elif len(sys.argv) < 2 or sys.argv[1] in ('-h', '--help'):
        print __doc__
20     return

    run(sys.argv[1:])

```

Modul rnaseqlyze.cli.xmltool

```

"""
RNA-Seqlyze xmltool

```

XML version of of `python -m json.tool`.

Takes an xml file or stream as input and pretty-prints it.

Usage:

rnas-xmltool <input.xml> <output.xml>

If <input.xml> is '-', use 'sys.stdin', if <output.xml> is '-', use 'sys.stdout'.
"""

```
import sys
```

```
from lxml import etree
```

```
def main():
```

```
    if len(sys.argv) < 2 or sys.argv[1] in ('-h', '--help'):
```

```
        print __doc__
```

```
        return
```

```
    inputfile = sys.argv[1] == '-' and sys.stdin or open(sys.argv[1])
```

```
    outputfile = sys.argv[2] == '-' and sys.stdout or open(sys.argv[2], "w")
```

```
    tree = etree.parse(inputfile,
```

```
                        etree.XMLParser(remove_blank_text=True))
```

```
    print >> outputfile, etree.tostring(tree.getroot(), pretty_print=True)
```

3.1.4 Package rnaseqlyze.web

Modul rnaseqlyze.web

"""

***pyramid.web** is a Pyramid Web Framework Application.*

*To learn more about the applications architecture, head over to the wonderful
 world of the pyramid web framework at <http://www.pylonsproject.org/>.*

*This application has been created using the ``pcreate`` command with the ``-s
 alchemy`` option to create and sqlalchemy scaffold. There is plenty of `very
 good documentation <<http://docs.pylonsproject.org/projects/pyramid/en/latest/\narr/project.html#scaffolds-included-with-pyramid>>`_ available on how to do it.*

*In case you have trouble with anything pyramid-related, use the `source code on
 github <<https://github.com/Pylons/pyramid>>`_ or ask 'mcdonc' on freenode irc
 `#pyramid <<http://webchat.freenode.net/?channels=#pyramid>>`_.*

"""

```
import logging
```

```
log = logging.getLogger(__name__)
```

```
from sqlalchemy import create_engine
```

```
from sqlalchemy.orm import sessionmaker, scoped_session
```

```
from pyramid.config import Configurator
```

```
#: the zope transaction extension
```

```
from zope.sqlalchemy import ZopeTransactionExtension
```

```

25 import rnaseqlyze
from rnaseqlyze.web.jsonx import jsonx
project_name = rnaseqlyze.project_name + "-web"

30 #: a session managed by
#: ZopeTransactionExtension
#:
#: - http://stackoverflow.com/a/6044925
#: - pyramid_tm (transaction manager) is configured
35 DBSession = scoped_session(sessionmaker(extension=ZopeTransactionExtension()))

#: an unmanaged session
#:
#: used by :meth:`rnaseqlyze.web.views.post`
40 #: because the session needs to be committed early there
DBSession_unmanaged = scoped_session(sessionmaker())

def main(global_config, **settings):
    """
45     Create and return a Pyramid WSGI application.
    """
    log.debug("rnaseqlyze.web version %s : main()" % rnaseqlyze.__version__)

    # make sure to be able to delete files created by webapp
    # as user/group www-data/www-data from the command line
    # (as user/group johndoe/www-data)
    import os
    os.umask(0002)

55     engine = create_engine(rnaseqlyze.db_url)
    DBSession.configure(bind=engine)
    DBSession_unmanaged.configure(bind=engine)

    config = Configurator(settings=settings)

60     config.add_renderer('jsonx', jsonx)

    config.scan()

65     config.add_route('home', '/')
    config.add_route('upload', '/upload')
    config.add_route('analyses', '/analyses')
    config.add_route('analysis', '/analyses/{id}')
    config.add_route('analysis_files', '/analyses/{id}/files*subpath')

70     config.add_route('analysis_rest', '/rest/analyses/{id}')
    config.add_route('analysis_logs_rest', '/rest/analyses/{id}/logs')
    config.add_route('analysis_files_rest', '/rest/analyses/{id}/files')

75     config.add_route('organisms_rest', '/rest/organisms')

    for path in 'less', 'css', 'img', 'js':
        config.add_static_view(path, path)

```

```

80     return config.make_wsgi_app()

from pyramid.events import subscriber
from pyramid.events import BeforeRender
from pyramid.renderers import get_renderer

85 @subscriber(BeforeRender)
def before_render(event):
    """
    This function is called by Pyramid after the view callable has returned
    and before the renderer (json / chameleon) is called. We inject some
    90 convenience functions and objects that are used in the `zope page
    templates <http://pagetemplates.org/docs/latest/reference.html>`_
    (.pt files) which `the chameleon template engine
    <http://pagetemplates.org/>`_ then renders.
    95 """

    base = get_renderer('templates/base.pt').implementation()

    rq = event['request']
    path = lambda sub: rq.route_path('home') + sub
    100 relpath = lambda sub: rq.current_route_path() + '/' + sub

    event.update({
        'base': base,
    105     'path': path,
        'relpath': relpath,
        'version': rnaseqlyze.__version__,
        'debug': log.getEffectiveLevel() <= logging.DEBUG,
    })

```

Modul rnaseqlyze.web.errors

```

"""
Pyramid Application Custom Error Views
"""

5 import logging
log = logging.getLogger(__name__)

from string import Template

10 from pyramid.view import view_config
from pyramid.response import Response, FileResponse
from pyramid.httpexceptions import (
    HTTPFound, HTTPError, HTTPServiceUnavailable, HTTPInternalServerError
)

15 import transaction
from sqlalchemy.exc import DBAPIError

import rnaseqlyze
20 from rnaseqlyze.web import DBSession, DBSession_unmanaged

```



```

from rnaseqlyze.core import service
from rnaseqlyze.core.entities import Analysis

@view_config(context=Exception)
25 def error(request):
    """
    **Exception view**

    This is a catch-all view that serves up any errors
30 that have occurred while processing the a request.

    The view just creates and returns a custom error response object.
    """
    return HTTPRNASeqError(request.exc_info)
35
class HTTPRNASeqError(HTTPError):
    """
    Custom HTTP Error class.

    This is a custom HTTP error class that extends
40 :class: `pyramid.httpexceptions.HTTPError`, which extends
:class: `pyramid.httpexceptions.WSGIHTTPException`. Have a look at the
source code <http://git.io/CqrfOg#L157>`_ to see how it works.

    It's ``code`` is 500, which generally means "Internal Server Error". If the
45 application is in debugging mode -- i.e. the log level is DEBUG or less, a
stack trace is added to the generated page as well as the log file.
Otherwise, an informational message is displayed and only one line,
containing the type of the error is logged.
50 """
    code = 500
    title = "RNA-Seqlyze Web Application Error"
    explanation = "An Exception was raised in rnaseqlyze.web"
    html_template_obj = Template(Template('\n'.join(map(lambda s: s[8:], ""\
55     <html>
        <head>
        <title>${title}</title>
        </head>
        <body style="margin: 20px;">
60     <h1>${title}</h1>
        ${body}
        </body>
        </html>
        """).split('\n')))).safe_substitute(title=title))
65 def __init__(self, exc_info):
    e = exc_info[1]
    log.error(repr(e))
    body_template = "<b>${explanation}</b>\n<hr/>\n"
    cls = e.__class__.__name__
70 if not e.args:
    self.explanation = "%s" % cls
else:
    self.explanation = "%s: %s" % (cls, e.args[0])

```

```

75         if log.getEffectiveLevel() > logging.DEBUG:           # no debug
            detail = production_error_msg % \
                    rnaseqlyze.admin_email
            body_template += "${detail}"
        else:                                                     # debug
80             detail = ''
            if isinstance(e, DBAPIError):
                detail += dberror_msg
            import traceback
            detail += '%s\n\nStack trace:\n' % e
85             detail += ''.join(traceback.format_tb(exc_info[2]))

            log.debug(detail)
            body_template += "<pre>\n${detail}</pre>"

90     HTTPError.__init__(self, detail, body_template=body_template)

    dberror_msg = """\
    This is a database related error.

95    If it is not yet initialized or the schema has changed,
    just run the "rnas-dbinit" script to (re-)initialize it.

    Afterwards, restart the Pyramid application, i.e. send a
    SIG_INT to the apache mod_wsgi daemon processes, and try again.
100    """

    production_error_msg = """\
    If you think that this is a bug, please contact the application administrator,
    %s, and inform him/her of the time the error occurred, and anything you might
105    have done that may have caused the error.
    Thank You!
    """

    # 'You' is intentionally capitalized! :-) Rule 84: http://goo.gl/BLBwX

```

Modul rnaseqlyze.web.jsonx

```

    """
    Pyramid JSON renderer that serializes arbitrary objects

    Copies the object's __dict__, looks up all attrs
5    in all base classes's __dict__'s on the object
    and then strips any unknown attribute types.
    """

    #import logging
10    #log = logging.getLogger(__name__)

    import json

    #: a custom json renderer
15    jsonx = lambda info: render_json

```

```

def render_json(value, system):
    """
    custom json renderer implementation
20
    based on http://git.io/a6BFGQ#L169
    """

    request = system.get('request')
25
    if request is not None:
        response = request.response
        response.content_type = 'application/json'
        return json.dumps(value, default=render_object, indent=4)

30
def render_object(obj):
    """
    "default" function for json.dumps()
    """

    attrs = dict((attr, getattr(obj, attr))
35
                  for base in obj.__class__.__mro__
                  for attr in base.__dict__
                  if attr[0] != '_')

    attrs.update(obj.__dict__)
40
    # log.debug(attrs)
    return dict(filter(filter_attributes, attrs.iteritems()))

none_type = type(None)
def filter_attributes(kv):
45
    """
    Helper function for render_object
    """

    if kv[0][0] != '_' and \
        type(kv[1]) in (none_type, bool, int, long, float, str, unicode, list):
50
        return True
    return False

```

Modul rnaseqlyze.web.rest

```

"""
Pyramid REST Views
"""

import logging
5
log = logging.getLogger(__name__)

import os

from pyramid.view import view_config
10

import rnaseqlyze
from rnaseqlyze.web import DBSession, DBSession_unmanaged
from rnaseqlyze.core import service
from rnaseqlyze.core.entities import Analysis, StageLog, UCSCOrganism
15

@view_config(route_name='analysis_rest', renderer='jsonx')

```

```

def display(request):
    """
    **REST Analysis View**
    """
    analysis = DBSession.query(Analysis).get(int(request.matchdict["id"]))
    first = DBSession.query(UCSCOrganism) \
        .filter(UCSCOrganism.acc.like(
            analysis.org_accession + '%')).first()
    org_db = first and first.db
    analysis.__dict__.update({
        'org_db': org_db,
        'hg_url': analysis.get_hg_url(org_db)})
    return analysis

@view_config(route_name='analysis_logs_rest', renderer='jsonx')
def analysis_stage_logs(request):
    """
    ***REST Stage Logs View***
    """
    criterion = StageLog.analysis_id == int(request.matchdict["id"])
    logs = DBSession.query(StageLog).filter(criterion).all()
    return sorted(logs, key=lambda log: log.id)

@view_config(route_name='analysis_files_rest', renderer='jsonx')
def analysis_files(request):
    """
    **REST Files View**
    """
    This view provides a (minimalistic, only GET is
    implemented) REST interface to '/analysis/{id}/files'.
    """
    files = []
    analysis = DBSession.query(Analysis).get(int(request.matchdict["id"]))
    os.chdir(analysis.data_dir)
    for dirpath, dirnames, filenames in os.walk("."):
        dir = dirpath[2:]
        for fn in filenames:
            files.append({'path': os.path.join(dir, fn)})
    return files

@view_config(route_name='organisms_rest', renderer='jsonx')
def organisms(request):
    """
    ***REST Organisms View***
    """
    Displays the list of organism titles
    along with their UCSC db and NCBI RefSeq accession identifiers
    """
    return DBSession.query(UCSCOrganism).all()

```

Modul rnaseqlyze.web.upload

```

"""
Pyramid Application Upload View

This module handles the upload of analysis files.

5 The upload interface consists of `plupload`
  (from http://www.plupload.com/) on the client
  and this hack on the server side. Combining the
  two and creating a working solution was not trivial.

10 Documentation and inspiration to create this
  was, amongst others, taken from the following documents:

  - http://www.plupload.com/documentation.php
15  - http://hg.python.org/cpython/file/2.7/Lib/cgi.py#l353
  - https://raw.githubusercontent.com/moziecode/plupload/master/examples/upload.php
  - https://github.com/hcwebdev/plupload/blob/master/examples/server.py
  - https://github.com/Pylons/webob/blob/master/webob/request.py#L102
  - https://hg.gawel.org/gp.fileupload/file/default/gp/fileupload/storage.py#l97
20 """

import logging
log = logging.getLogger(__name__)

25 import transaction
from pyramid.view import view_config

from rnaseqlyze.web import DBSession
from rnaseqlyze.core import service
30 from rnaseqlyze.core.entities import UploadSession

@view_config(route_name='upload', request_method='POST', renderer="json")
def upload(request):
    log.debug("upload(): content-type '%s'" % request.content_type)
    fs = FieldStorage(fp=request.environ['wsgi.input'], environ=request.environ)
35     return dict(jsonrpc="2.0", result=None, id=None)

import cgi
class FieldStoragex(cgi.FieldStorage):
40     def __init__(self, fp=None, headers=None, outerboundary="",
                  environ=None, keep_blank_values=0, strict_parsing=0):
        self.environ = environ
        cgi.FieldStorage.__init__(self, fp, headers, outerboundary,
                                  environ, keep_blank_values, strict_parsing)

45     if self.filename:
        return
    assert len(self.value) < 1000
    if self.name == 'session':
        environ['rnaseqlyse.upload_session'] = \
50         DBSession.query(UploadSession).get(int(self.value))
    elif self.name in ('name', 'type'):
        environ['rnaseqlyse.upload_' + self.name] = self.value
    else:
        return

```

```

55         log.debug("FieldStoragx(%s -> %s)" % (self.name, self.value))

        def make_file(self, binary=None):

            assert self.filename
60         log.debug("FieldStoragx.make_file(%s)" % self.filename)

            args = {}
            for kw in 'session', 'name', 'type':
                args[kw] = self.environ['rnaseqlyze.upload_' + kw]
65

            fd = service.get_uploadfile(DBSession, **args)
            # commit the (managed) session early here, so later
            # requests can re-use the Analysis object that the
            # first one has implicitly created by calling
70         # service.get_uploadfile
            import transaction
            transaction.commit()

            return fd

```

Modul rnaseqlyze.web.views

```

"""
Pyramid Application User Views
"""

5  import logging
    log = logging.getLogger(__name__)

    import re
    from os.path import join
10

    from pyramid.view import view_config
    from pyramid.response import FileResponse
    from pyramid.httpexceptions import HTTPFound

15  import transaction
    from sqlalchemy.exc import DBAPIError

    import rnaseqlyze
    from rnaseqlyze import galaxy
20  from rnaseqlyze.web import DBSession, DBSession_unmanaged
    from rnaseqlyze.core import service
    from rnaseqlyze.core.entities import Analysis, UCSCOrganism

    autocomplete_re = re.compile(r"^[^()]+\([^/]+/([~])+\).*")
25

    @view_config(route_name='home', renderer='templates/home.pt')
    def home(request):
        """
        **Home Page**
30

        This is the main entry point to the application. I.e. the landing page,

```

```

        the page that users see first.
        """
        return {}
35
    @view_config(route_name='analyses', renderer='templates/create.pt')
    def create(request):
        """
        **Create Page**
40
        This page is shown when the "New Analysis" button is clicked.
        """
        sess = service.get_upload_session(DBSession)
        return { 'upload_session': sess.id }
45
    @view_config(route_name='analysis', renderer='templates/analysis.pt')
    def display(request):
        """
        **Analysis Page**
50
        This page is displayed after the the anaysis has been created.
        When the user clicks "Submit" on the 'create' page, after
        the files are uploaded and the form information is submitted
        to the :func:`~post` view, the browser is redirected here.
55
        The page can also be viewed any time later on, no matter
        weather the analysis has already been completed or not.

        In case it is not yet completed, the page is constantly
        updated via XMLHttpRequests to reflect the current status.
60
        """

        id = int(request.matchdict["id"])
        return {
65
            'analysis': DBSession.query(Analysis).get(id),
            'galaxy_history_url': galaxy.default_history_url,
        }

    @view_config(route_name='analysis_files')
70 def analysis_files(request):
        """
        **Files View**

        This view serves up the files associated with
75 an analysis on 'http://<rnaseqlyze>/analysis/{id}/files'.
        """
        return FileResponse(join(rnaseqlyze.analyses_path,
                                request.matchdict['id'], *request.subpath))

80 import mimetypes
    #mimetypes.add_type("text/plain", ".")
    #mimetypes.add_type("text/plain", ".")
    #mimetypes.add_type("text/plain", ".")
    #mimetypes.add_type("text/plain", ".")
85 mimetypes.add_type("text/plain", ".gb")

```

```

mimetypes.add_type("text/plain", ".log")
mimetypes.add_type("text/plain", ".log0")
mimetypes.add_type("text/plain", ".info")
# FileResponse automatically sets the Content-Type header based on this
90
@view_config(route_name='analyses', request_method='POST')
def post(request):
    """
    **Create-Form Action**
95
    This view just redirects the client to the created analysis page.
Before it is actually called, the files to be analyzed, are uploaded
using the :func:`~.upload.upload` view callable.
    """
100
    # for documentation on the documentation reference syntax, see
    # http://sphinx.pocoo.org/domains.html#cross-referencing-python-objects

    # TODO: csrf security checks
    # see "shootout" pyramid demo app
105

    # note:
    # when using the "DBSession" (managed), the
    # try:/except: rollback construct is not needed
    # because the session is automatically rolled back
110
    # otoh, if the _unmanaged session is used, it _has_ to
    # be manually committed or rolled back if objects are modified

    if 'org_accession' in request.POST:
        request.POST['org_accession'] = \
115
            autocomplete_re.sub(r"\1", request.POST['org_accession'])
    try:
        analysis = service.get_analysis(
            DBSession_unmanaged, attributes=request.POST)

120
        # the analysis must exist in the database
        # so the worker can find it and start working
        DBSession_unmanaged.commit()

        service.start_analysis(analysis)
125
        log.debug("started analysis #%d by '%s'" % (
            analysis.id, analysis.owner.name))

        return HTTPFound(request.route_path('analysis', id=analysis.id))
    except:
130
        log.info("abort")
        DBSession_unmanaged.rollback()
        log.debug("rollback complete")
        raise

```

Modul rnaseqlyze.web.wsgi

```

"""
RNA-Seqlyze WSGI Application

```



```

Provides the get_app(workdir) function,
5 which returns a wsgi application callable.
  """

def get_app(workdir):
  """
10 Basically returns wrapper around paster.get_app
   that strips the ".wsgi" extension from SCRIPT_NAME
   """

   # configure the core package
15   import rnaseqlyze
   rnaseqlyze.configure(workdir)

   # default configuraion file name
   import os.path
20   web_ini = os.path.join(workdir, 'web.ini')

   # configure logging
   import logging.config
   logging.config.fileConfig(web_ini, dict(here=workdir))
25

   # create the pyramid wsgi app
   import pyramid.paster
   pyramid_app = pyramid.paster.get_app(web_ini, 'main')

30   # return a wrapper that adjusts SCRIPT_NAME
   def app(environ, start_request):
       environ['SCRIPT_NAME'] = \
           environ['SCRIPT_NAME'][:-5]
       return pyramid_app(environ, start_request)
35

   return app

```

3.1.5 Package rnaseqlyze.worker

Modul rnaseqlyze.worker

```

"""
**pyramid.worker** is a Pyramid Web Framework Application.

The framework is used here to keep things simple. Even though not many of the
5 frameworks features are used, building this "-worker" part of the project as a
Pyramid Web Framework Application, just like the "-web" part, hopefullly makes
it easy to understand for anybody already understanding the "-web" part.

The key features from then Pyramid Web Framework used here, are
10

1) The "pserve" command, which makes running the application as a unix daemon
   process very simple. It's direct use has actually been depreciated during
   the development and a custom command, "rnas-worker", has been created,
   which uses the same python functions and modules like "pserve".
15

```

2) The `pyramid.config.Configurator` class, that is used to define the applications "routes" and "view callables". These "views" provide the applications interface. They are served on a tcp port bound to localhost (127.0.0.1) and are therefore only available to processes running on the same host.

The "-worker" applications interface has "HTTP-like" semantics.

The following commands are accepted:

- ``GET /analyses/{id}``: Show the current status.
- ``START /analyses/{id}``: Start processing an analysis.

Only for development purposes, one additional command exists:

- ``RESTART /analyses/{id}``: Restart an analysis that has already been started.

The commands are executed by the "-web" part of the application by subclassing `HTTPRequest` and overriding the `get_method()` function. They can also be executed from the command line however, using the popular "curl" binary with the "-X" option, e.g.

- ``curl -X GET localhost:/analyses/3``
- ``curl -X START localhost:/analyses/3``
- ``curl -X RESTART localhost:/analyses/3``

"""

```

45 import logging
log = logging.getLogger(__name__)

from pyramid.view import view_config
from pyramid.view import view_defaults
50 from pyramid.config import Configurator
from pyramid.response import Response
from pyramid.httpexceptions import (
    HTTPError,
    HTTPBadRequest,
55     HTTPInternalServerError,
)

from sqlalchemy import create_engine
from sqlalchemy.orm import sessionmaker, scoped_session
60 from zope.sqlalchemy import ZopeTransactionExtension

import rnaseqlyze
project_name = rnaseqlyze.project_name + "-worker"

65 from rnaseqlyze.core.entities import Analysis
from rnaseqlyze.worker.core import (
    Manager,
    ManagerBusyException,
    AnalysisAlreadyStartedException,

```

```

70 )

DBSession = scoped_session(sessionmaker(extension=ZopeTransactionExtension()))

def main(global_config, **settings):
75     """
    Return a Pyramid(!) WSGI application.
    """

    # make sure to be able to delete files created by webapp
    # as user/group www-data/www-data from the command line
    # (as user/group johndoe/www-data)
80     import os
    os.umask(0002)

    engine = create_engine(rnaseqlyze.db_url)
    DBSession.configure(bind=engine)

    Waitress.manager = Manager()

90     config = Configurator(settings=settings)
    config.add_route('analyses', '/analyses/{id}')
    config.scan()
    return config.make_wsgi_app()

95 @view_defaults(route_name='analyses', renderer='string')
class Waitress(object):

    def __init__(self, request):
100         id = int(request.matchdict['id'])
        self.analysis = DBSession.query(Analysis).get(id)

    @view_config(request_method='GET')
    def status(self):
105         import pprint
        return pprint.pformat({
            'context': self, # Waitress
            'manager': self.manager, # Manager
            'analysis': self.analysis, # Analysis
110         })

    @view_config(request_method='START')
    def start(self):
        self.manager.analysis_requested(self.analysis)
115         return "started analysis #%d" % self.analysis.id

    @view_config(request_method='RESTART')
    def restart(self):
        self.manager.analysis_requested(self.analysis, True)
120         return "restarted analysis #%d" % self.analysis.id

    @view_config(context=Exception)

```

```

def error_view(error, request):
125     errdict = {
        AnalysisAlreadyStartedException: HTTPBadRequest,
        ManagerBusyException: HTTPInternalServerError,
    }
    if isinstance(error, HTTPError):
130         return error
    elif type(error) in errdict:
        return errdict[type(error)](error)
    else:
        return HTTPInternalServerError(error)
135

# monkey-patch some HTTPException classes to get simpler error messages

from pyramid.response import Response
140 def _WHE_init(self, arg=None):
    Exception.__init__(self, arg)
    if isinstance(arg, Exception):
        if False: # production
            e, t = arg, type(arg)
            arg = "%s %s" % (t.__name__, e.args)
145         else: # debug
            import traceback
            arg = traceback.format_exc(999)
    Response.__init__(self,
150         '%s %s\n\n%s' % (self.code, self.title, arg),
        content_type='text/plain', status='%s %s' % (self.code, self.title))

from pyramid.httpexceptions import WSGIHTTPException
WSGIHTTPException.__init__ = _WHE_init
155 del WSGIHTTPException.__call__
del WSGIHTTPException.prepare

```

Modul rnaseqlyze.worker.core

```

"""
RNA-Seqlyze Worker Daemon Core

Worker parent class with basic infrastructure to run the
5 various analysis steps defined in :class:`~.WorkerStages`.
"""

import logging
log = logging.getLogger(__name__)
10 root_logger = logging.getLogger()

from threading import Thread
from logging import Formatter
from logging import StreamHandler
15 from StringIO import StringIO
from contextlib import contextmanager

```

```

from sqlalchemy import create_engine
from sqlalchemy.orm import sessionmaker

20
import rnaseqlyze
from rnaseqlyze import efetch
from rnaseqlyze.core.entities import Analysis, StageLog
from rnaseqlyze.worker.stages import WorkerStages

25
DBSession = sessionmaker()

log_format = "%(levelname)-5.5s [%s] %(message)s"

30
class Manager(object):
    def __init__(self):
        self.worker = Thread()

    def analysis_requested(self, analysis, re=False):
35
        if analysis.started and not re:
            raise AnalysisAlreadyStartedException
        if self.worker.is_alive():
            raise ManagerBusyException
        self.worker = Worker(analysis)
40
        self.worker.start()

class StageLogStream(object):
    def __init__(self, analysis, stage, session):
        self.stage_log = StageLog(analysis=analysis, stage=stage, text="")
45
        self.session = session
        session.add(self.stage_log)
        session.commit()
    def write(self, data):
        self.stage_log.text += data
50
        self.session.commit()

class AnalysisAlreadyStartedException(Exception):
    pass

55
class ManagerBusyException(Exception):
    pass

class Worker(Thread, WorkerStages):
    """
60
    The Worker
    """

    def __init__(self, analysis):
        Thread.__init__(self)
65
        self.analysis_id = analysis.id

    def _thread_init(self):
        from os import path
        self.session = DBSession(bind=create_engine(rnaseqlyze.db_url))
70
        self.analysis = self.session.query(Analysis).get(self.analysis_id)

```

```

self.logfile = open(path.join(
    self.analysis.data_dir, "rna-seqlyze-worker.log"), "w")
self.log_handler = StreamHandler(self.logfile)
75 self.log_handler.setFormatter(Formatter(log_format))
root_logger.addHandler(self.log_handler)
log.info("starting work on analysis #%d" % self.analysis_id)
self.analysis.finished = False
self.analysis.started = True
80 self.analysis.error = None
self.session.commit()

@contextmanager
def _stage_log_manager(self, stage):
85 handler = StreamHandler(
    StageLogStream(self.analysis, stage, self.session))
root_logger.addHandler(handler)
try:
    yield
90 finally:
    root_logger.removeHandler(handler)

def run(self):

95 # TODO: invent a way to avoid calling stages that won't do anything
#     maybe @stages -> @stages(condition) something ...

self._thread_init()
try:
100 for stage in self.stages:
    if not stage.should_run(self):
        continue
    log.info("=== %s ===" % stage.func_name)
    with self._stage_log_manager(stage.func_name):
105 self.analysis.stage = stage.func_name
self.session.commit()
stage(self)
except Exception, e:
    self.analysis.error = repr(e)
110 raise
finally:
    if self.analysis.error:
        log.error(self.analysis.error)
    else:
115 log.info("analysis finished")

self.analysis.finished = True
self.session.commit()
root_logger.removeHandler(self.log_handler)
120 self.logfile.close()

```

Modul rnaseqlyze.worker.daemon

```

"""
RNA-Seqlyze Worker

Start, stop or restart the worker daemon
5 or run it in the foreground, in development mode.

Usage:
    rnas-worker <workdir> (start|stop|restart)
    rnas-worker <workdir> --development
10    rnas-worker -h|--help

Arguments:

    <workdir> The path to the workers 'workdir'.
15    The 'workdir' is where the configuration, the
        application database and all analysis data are stored.

    start|stop|restart

20    If one of those arguments is given, the daemon is
        run in the background. It will write it's PID to the
        file <workdir>/worker-daemon.pid and its output will be logged
        to <workdir>/worker-daemon.log. This is not the "log file"
        however. The "log file" path can be configured
25    in <workdir>/worker.ini.

    --development

30    If this argument is present, the worker daemon is run in
        development mode, which means that it will no fork to the
        background. If any source files (.py) are changed when the
        daemon is running in development mode, it will be
        automatically restarted.

35 """

from os.path import abspath, join

from paste.script import serve
40 import docopt

import rnaseqlyze

def main():
45     opts = docopt.docopt(__doc__)

    for command in "start|stop|restart".split('|'):
        if opts[command]:
            mode = "production"
            args = [command, "--daemon"]
50             break
        else:
            mode = "development"
            args = ["--reload"]

```

```

55     workdir = abspath(opts['<workdir>'])
        rnaseqlyze.configure(workdir)

        if mode == 'production':
60             args.extend([
                    "--user=" + rnaseqlyze.worker_user,
                    "--group=" + rnaseqlyze.group,
                    "--log-file=" + join(workdir, 'worker-daemon.log'),
                    "--pid-file=" + join(workdir, 'worker-daemon.pid'),
65             ])

        conf_file = join(workdir, 'worker.ini')
        serve.ServeCommand("serve").run([conf_file] + args)

```

Modul rnaseqlyze.worker.stages

```

"""
RNA-Seqlyze Worker Stages

    -- **this** is where things are actually getting done! :-)
5  """
import logging
log = logging.getLogger(__name__)

import os
10 from os.path import join, exists, isdir, relpath
    from subprocess import Popen, PIPE
    from StringIO import StringIO
    from threading import Thread
    from urllib import quote

15 import pysam

from Bio import SeqIO
from Bio.SeqFeature import \
20     SeqFeature, FeatureLocation, ExactPosition

from psutil import cpu_percent

from rnaseqlyze import efetch
25 from rnaseqlyze import galaxy
    from rnaseqlyze import ucscbrowser
    from rnaseqlyze import transterm, gb2ptt
    from rnaseqlyze.ucscbrowser import BAMTrack, BigWigTrack, BigBedTrack
    from rnaseqlyze.core.entities import GalaxyDataset
30

class Operon(object):
    def __init__(self, **kwargs):
        self.__dict__.update(kwargs)

35 _stages = []
_stage_conds = {}

```



```

def stage(method):
    """
40     Just a small helper to collect the stages in the order defined.

    To add a new stage, simply add a method to :class:`~WorkerStages`.
    It will be automatically executed for all new analyses.
    """
45     if method.func_name in _stage_conds:
        method.should_run = _stage_conds[method.func_name]
        del _stage_conds[method.func_name]
    else:
        method.should_run = lambda self: True
50     _stages.append(method)
    return method

def stage_cond(method):
    """
55     Stage Condition

    - must be declared before @stage
    - must return true for the @stage of the same name to run
    """
60     _stage_conds[method.func_name] = method

class WorkerStages(object):
    """
    Available attributes:
65
    - self.analysis
    - self.session = DBSession(bind=create_engine(rnaseqlyze.db_url))

    .. note::
70     After changing one of the attributes of the self.analysis object,
    **always** **immediately** call self.session.commit(). Otherwise
    the database will stay locked and the web frontend can't update the ui.

    """
75
    #####
    # Utility Methods & Properties

80     def log_cmd(self, *cmd):
        # can't wait() on subprocess with a timeout, alas start up
        # a 2nd thread to do it and join() on that one with a timeout
        log.info("forking subprocess: $ %s" % ' '.join(map(repr, cmd)))
        proc = Popen(cmd, stdout=self.logfile, stderr=self.logfile)
85         waiter = Thread(target=proc.wait)
        cpu_percent(0, True)
        waiter.start()
        waiter.join(15)
        while waiter.is_alive():
90             log.info("subprocess still running - system load: " +
                       " / ".join(("d%" % p for p in cpu_percent(0, True))))

```

```

        waiter.join(15)
        if proc.returncode != 0:
            raise Exception("%s failed" % (cmd,))
95
@property
def srr_name(self):
    return self.analysis.inputfile_base_name

100
@property
def bam_name(self):
    return "%s %s Mapping" % (self.genbank_record.id, self.srr_name)

@property
105
def coverage_name(self):
    return "%s %s Coverage" % (self.genbank_record.id, self.srr_name)

@property
def hp_terms_name(self):
110
    return "%s Hairpin Terminators" % (self.genbank_record.id,)

@property
def pr_operons_name(self):
    return "%s Predicted Operons" % (self.genbank_record.id,)
115

#
#####
# Stages

120
@stage_cond
def determine_inputfile_type(self):
    return self.analysis.inputfile_uploaded

@stage
def determine_inputfile_type(self):
125
    _8bytes = open(self.analysis.inputfile_path).read(8)
    log.info("first 8 bytes of input data: %r" % _8bytes)
    self.analysis.inputfile_type = (
        'fastq' if _8bytes[0] == '@'
        else 'sra' if _8bytes == 'NCBI.sra' else None)
130
    self.session.commit()
    if not self.analysis.inputfile_type:
        raise Exception("Unknown input data type")

@stage_cond
135
def fetch_srr(self):
    # don't download if private
    # file uploaded or srr already in cache
    return not self.analysis.inputfile_uploaded \
        and not os.path.exists(self.analysis.rnaseq_run.sra_path)

140
@stage
def fetch_srr(self):
    self.analysis.rnaseq_run.download()

@stage_cond
145
def convert_input_file(self):

```

```

        return not exists(self.analysis.inputfile_fq_path)
    @stage
    def convert_input_file(self):
        os.chdir(self.analysis.input_data_dir)
150         self.log_cmd("fastq-dump", "-B", self.analysis.inputfile_name)
        log.debug("created %s" % self.analysis.inputfile_fq_path)

    @stage_cond
    def fetch_genbank_file(self):
155         return not exists(self.analysis.genbankfile_path)
    @stage
    def fetch_genbank_file(self):
        if not exists(self.analysis.genbank_data_dir):
            os.makedirs(self.analysis.genbank_data_dir)
160         log.info("Fetching '%s' from entrez..." %
                    self.analysis.org_accession)
        gb_id = efetch.get_nc_id(self.analysis.org_accession)
        efetch.fetch_nc_gb(gb_id, open(self.analysis.genbankfile_path, "w"))
        log.info("...done")
165
    @stage
    def read_genbank_file(self):
        self.genbank_record = SeqIO.parse(open(self.analysis \
                                                .genbankfile_path), "genbank").next()
170         ngenes = sum(1 for f in self.genbank_record.features
                        if f.type == 'gene')
        log.info("genbank file lists %d genes" % ngenes)

    @stage_cond
    def genbank_to_fasta(self):
175         return not exists(self.analysis.genbankfile_fa_path)
    @stage
    def genbank_to_fasta(self):
        log.info("Converting '%s' to fasta format" %
180                    self.analysis.genbankfile_name)

        record = self.genbank_record
        saved_id = record.id
        record.id = "chr" # make ucsc browser custom tracks work
        SeqIO.write(record, open(
185             self.analysis.genbankfile_fa_path, "w"), "fasta")
        record.id = saved_id

    @stage_cond
    def bowtie_build(self):
190         return not exists(join(self.analysis.genbank_data_dir,
                                self.analysis.genbankfile_base_name + ".1.bt2"))
    @stage
    def bowtie_build(self):
        os.chdir(self.analysis.genbank_data_dir)
195         self.log_cmd("bowtie2-build", self.analysis.genbankfile_fa_name,
                        self.analysis.genbankfile_base_name)

    @stage_cond
    def tophat(self):

```

```

200         return not exists(join(self.analysis.data_dir,
                                "tophat-output", "accepted_hits.bam"))

    @stage
    def tophat(self):
        os.chdir(self.analysis.data_dir)
        n_cpus = os.sysconf("SC_NPROCESSORS_ONLN")
205         fq = relpath(self.analysis.inputfile_fq_path)
        gb = relpath(join(self.analysis.genbank_data_dir,
                           self.analysis.genbankfile_base_name))
        self.log_cmd("tophat",
210                      "-p", str(n_cpus),
                      "-o", "tophat-output",
                      "--segment-length", "999999999",
                      "--no-coverage-search", "--no-novel-juncs", gb, fq)

215    @stage_cond
    def create_coverage_track(self):
        return not exists(join(self.analysis.data_dir, "coverage.bigwig"))

    @stage
    def create_coverage_track(self):
220         os.chdir(self.analysis.data_dir)
        # the script automatically converts it's
        # output to bigwig if it finds kent's wigToBigWig
        self.log_cmd("bam_to_wiggle.py", "-o", "coverage.bigwig",
225                      "tophat-output/accepted_hits.bam")

225    @stage_cond
    def genbank_to_ptt(self):
        return not exists(join(self.analysis.genbank_data_dir,
                                self.genbank_record.id + ".ptt"))

230    @stage
    def genbank_to_ptt(self):
        ptt_name = self.genbank_record.id + ".ptt"
        ptt_path = join(self.analysis.genbank_data_dir, ptt_name)
        os.symlink(ptt_name, join(self.analysis.genbank_data_dir, "chr.ptt"))
235         log.debug("converting %s to ptt" % self.analysis.genbankfile_name)
        ptt_file = open(ptt_path, "w")
        gb_file = open(self.analysis.genbankfile_path)
        gb2ptt.gb2ptt(gb_file, ptt_file)
        ptt_file.close()
240         gb_file.close()

    @stage_cond
    def transterm_hp(self):
        return not exists(join(self.analysis.data_dir,
                                "hp_terminators.bigbed"))

245    @stage
    def transterm_hp(self):
        os.chdir(self.analysis.data_dir)
        log.debug("running transterm")

250         tt_out = open("transterm_hp.out", "w+")
        # --min-conf=n n is the cut-off confidence value,
        #                     between 0 and 100, the default is 76

```

```

255     tt_args = ("--min-conf=47",
                self.analysis.genbankfile_fa_path,
                relpath(join(self.analysis.genbank_data_dir, "chr.ptt")))
    transterm.run(tt_args, out=tt_out, err=self.logfile)
    tt_out.seek(0)
    # keep a copy in memory
260     self.hp_terminators = list(transterm.iterator(tt_out))
    tt_out.seek(0)
    log.info("found {0} possible hairpin terminators"
            .format(len(self.hp_terminators)))

    # create a bed track
265     bed_file = open("hp_terminators.bed", "w")
    transterm.tt2bed(tt_out, bed_file)
    bed_file.close()
    tt_out.close()

270     log.debug("running bedToBigBed")

    # convert it to bigBed
    chrs = open("chrom.sizes", "w")
    chrs.write("chr %d" % len(self.genbank_record.seq))
    chrs.close()
275     self.log_cmd("bedToBigBed", "hp_terminators.bed",
                  "chrom.sizes", "hp_terminators.bigbed")

    @stage
280     def predict_operons(self):

        # extract the coverage data from the bam track created by tophat
        bam_path = join(join(self.analysis.data_dir,
                             "tophat-output", "accepted_hits.bam"))
285         if not exists(bam_path + ".bai"):
            pysam.index(bam_file)

        self.max = 0
        self.covered = 0
290         self.coverage = [0] * len(self.genbank_record.seq)

        sam_reader = pysam.Samfile(bam_path, "rb")
        chrom, length = sam_reader.references[0], sam_reader.lengths[0]

295         assert chrom == "chr" and length == len(self.genbank_record.seq), (
            "Something went badly wrong"
            " -- the bam track or genbank file could be corrupted...")

        for base in sam_reader.pileup(chrom, 0, length):
300             self.covered += 1
            if base.n > self.max:
                self.max = base.n
            self.coverage[base.pos] = base.n

305         if not self.covered:
            raise Exception("Not a valid bam file")

```

```

log.debug("maximum coverage: %d" % self.max)
log.debug("number of bases covered by short reads: %d/%d" % (
310         self.covered, len(self.genbank_record.seq)))

# available objects at this point
# -----
#
315 # - self.genbank_record: Biopython SeqIO.parse()d genbank file
#
# - self.coverage: [n,n,n,n,...] / len = len(self.genbank_record.seq)
#
# - self.max: max(n)
320 #
# - self.hpterminalators: ((id, begin, end, strand, confidence), ...)
#         str, str, str, str (1/-), int
#

325 # FIXME: this is just a dummy implementation, that predicts an
#         operon for every transcribed (i.e. coverage > 1) region

self.operons = []

330 operon = None
for i, n in enumerate(self.coverage):
    if n > 0:
        if not operon:
            operon = Operon(begin=i + 1, strand=1, confidence=1)
335        else:
            if operon:
                operon.end = i
                self.operons.append(operon)
                operon = None

340 # create a bed track
track_name = "rna-seqlyze-operon_predictions"
os.chdir(self.analysis.data_dir)
bed_file = open(track_name + ".bed", "w")
345 for i, o in enumerate(self.operons):
    begin, end = str(o.begin), str(o.end)
    rgb_color = ','.join((str(100 - int(o.confidence))),*3)
    print >> bed_file, '\t'.join((
        'chr', begin, end,
350        'OPERON_%d' % i, str(o.confidence),
        '+ ' if o.strand > 0 else '-', begin, end, rgb_color
    ))
bed_file.close()

355 # convert it to bigBed
# chrom_sizes already generated during "transterm_hp"
self.log_cmd("bedToBigBed", track_name + ".bed",
             "chrom.sizes", track_name + ".bigbed")

360 @stage
def upload_track_data(self):

```

```

# FIXME: names are not unique on galaxy:
# is "%s_%s" % (srr_name, self.analysis.org_accession) good enough ?
365
if not self.analysis.galaxy_bam:
    bam_path = join(self.analysis.data_dir,
                    "tophat-output", "accepted_hits.bam")
    log.info("uploading accepted_hits.bam to galaxy")
370
    self.analysis.galaxy_bam = GalaxyDataset(
        id=galaxy.upload(open(bam_path), self.bam_name))
    log.info("...done - id: %s" % self.analysis.galaxy_bam.id)
    self.session.commit()

375
if not self.analysis.galaxy_coverage:
    coverage_path = join(self.analysis.data_dir, "coverage.bigwig")
    log.info("uploading coverage.bigwig to galaxy")
    self.analysis.galaxy_coverage = GalaxyDataset(
        id=galaxy.upload(open(coverage_path), self.coverage_name))
380
    log.info("...done - id: %s" % self.analysis.galaxy_coverage.id)
    self.session.commit()

if not self.analysis.galaxy_hp_terms:
    hp_terms_path = join(self.analysis.data_dir,
                        "hp_terminators.bigbed")
385
    log.info("uploading hp_terminators.bigbed to galaxy")
    self.analysis.galaxy_hp_terms = GalaxyDataset(
        id=galaxy.upload(open(hp_terms_path), self.hp_terms_name))
    log.info("...done - id: %s" % self.analysis.galaxy_hp_terms.id)
390
    self.session.commit()

if not self.analysis.galaxy_pr_operons:
    track_filename = "rna-seqlyze-operon_predictions.bigbed"
    pr_operons_path = join(self.analysis.data_dir, track_filename)
395
    log.info("uploading %s to galaxy" % track_filename)
    self.analysis.galaxy_pr_operons = GalaxyDataset(
        id=galaxy.upload(open(pr_operons_path), self.pr_operons_name))
    log.info("...done - id: %s" %
              self.analysis.galaxy_pr_operons.id)
400
    self.session.commit()

@stage
def create_and_upload_hg_text(self):
    """
405
    ``hgt.customText`` is a parameter of the UCSC
    "hgTracks" genome browser application that makes it
    possible to share "custom tracks" via a url.

    The value of the ``hgt.customText`` parameter is itself
    an URL. The shareable "custom tracks url" is therefore an
410
    URL that contains another URL. The other url must be "escaped"
    for this to work. That actually happens in
    :meth:`~rnaseqlyze.core.analysis.AnalysisMixins.hg_url`.

415
    The details are explained here:
    http://genome.ucsc.edu/goldenPath/help/customTrack.html#SHARE

```

```

"""

if self.analysis.galaxy_hg_text:
420     return

tracks = []

# FIXME: this cries for refactoring -- with logging!
425

# bam track (mapping)
bam_url = "https://" + galaxy.hostname \
          + galaxy.ucsc_bam_path_template \
            .format(dataset=self.analysis.galaxy_bam.id)
430 tracks.append(BAMTrack(url=bam_url,
                          name="RNA-Seqlyze | %s" % self.bam_name))

# bigwig track (coverage)
coverage_url = "https://" + galaxy.hostname \
435           + galaxy.dataset_display_url_template \
            .format(dataset=self.analysis.galaxy_coverage.id)
tracks.append(BigWigTrack(url=coverage_url,
                          name="RNA-Seqlyze | %s" % self.coverage_name))

440 # bigbed track (terminators)
hp_terms_url = "https://" + galaxy.hostname \
               + galaxy.dataset_display_url_template \
                 .format(dataset=self.analysis.galaxy_hp_terms.id)
tracks.append(BigBedTrack(url=hp_terms_url,
445                          name="RNA-Seqlyze | %s" % self.hp_terms_name))

# bigbed track (predicted operons)
pr_operons_url = "https://" + galaxy.hostname \
450           + galaxy.dataset_display_url_template \
            .format(dataset=self.analysis.galaxy_pr_operons.id)
tracks.append(BigBedTrack(url=pr_operons_url,
                          name="RNA-Seqlyze | %s" %
455                          self.pr_operons_name))

track_file = StringIO()
track_file.write('\n'.join(tracks))
track_file.seek(0)
self.analysis.galaxy_hg_text = GalaxyDataset(
460     id=galaxy.upload(track_file,
                       "UCSC Tracks Analysis%d.txt" %
                       self.analysis.id))

self.session.commit()

@stage
465 def create_genbank_file(self):
    """
    Create a genbank file containing

    For more documentation on how to create new features, visit
470

```



```

- http://biopython.org/\
    DIST/docs/api/Bio.SeqRecord.SeqRecord-class.html#__getitem__
- http://biopython.org/\
    DIST/docs/api/Bio.SeqFeature.SeqFeature-class.html
475
- http://www.ebi.ac.uk/\
    embl/Documentation/FT_definitions/feature_table.html
"""

480 log.info("augmenting genbank file %s with putative operons" %
          self.analysis.genbankfile_name)

for i, o in enumerate(self.operons):
    location = FeatureLocation(ExactPosition(o.begin),
485                               ExactPosition(o.end))
    self.genbank_record.features.append(
        SeqFeature(location,
                    type='mRNA',
                    strand=o.strand,
490                    qualifiers=dict(
                        note='putative, confidence %d%%' % o.confidence,
                        operon='rnas-%d' % i)))

    self.genbank_record.features.sort(
495        key=lambda f: f.location.start.position)

    xgb_file = open(self.analysis.xgenbankfile_path, "w")

    SeqIO.write(self.genbank_record, xgb_file, "genbank")
500 #
    #####

assert not _stage_conds, "@stage_cond's must be declared before @stage's"
WorkerStages.stages = _stages
505 del _stages, _stage_conds

```

3.1.6 Javascript Code

rnaseqlyze.js

```

/*
 * RNA-seqlyze javascript routines
 */

5 $(function() {

    // global variables and helpers
    // -----

10    // --- el ---
    // from http://joestelmach.github.com/laconic/
    window.el = $.el;

```

```

// log.info() and log.debug()
15 window.log = {
    'info': function() {
        console.log.apply(console, arguments);
    },
    'debug': function() {}
20 }
if (rnaseqlyze_debug)
    window.log.debug = window.log.info;

// page initializaion
25 // -----

// use bootstrap's
// "scrollspy" plugin
// -- patched version - see https://github.com/twitter/bootstrap/pull/3829
30 $(window).scrollspy({
    // offset: 200,
    wrap: $('#wrap')[0],
});

35 // Generally useful stuff
// -----

// based on http://stackoverflow.com/a/4673436
40 String.prototype.format = function() {
    var i = 0; args = arguments;
    return this.replace(/{} /g, function() {
        return args[i++];
45 });
});

50 // http://stackoverflow.com/a/7531350
jQuery.fn.extend({
    scrollToBottom: function () {
        var top = $(this).offset().top;
        var offtop = top - 250 + $(this).height();
55 jQuery('html,body').animate({scrollTop: offtop}, 100);
    },
});

```

rnaseqlyze-create.js

```

/*
* RNA-seqlyze javascript routines
*
* for the "create" page
5 */

```

```

$(document).ready(function() {

    /*
10     * Toggle input type
    */

    $('#input_type_radio').click(function(event) {
        if ($(event.target).hasClass("srr")) {
15            // user chose the "Data File" option
            $('#sra-controls').hide();
            $('#srr-controls').show();
        } else if ($(event.target).hasClass("sra")) {
            // user chose the "SRR Identifier" option
20            $('#srr-controls').hide();
            $('#sra-controls').show();
        } // else
            // what the...
    });
25    $('#input_type_radio .srr').click();

    /*
    * discretionary #pairendlenControls
    */
30

    function maybe_show_pairendlen_controls() {
        if ($('#pairendedInput').attr('checked'))
            $('#pairendlenControls').show();
        else
35            $('#pairendlenControls').hide();
    }

    maybe_show_pairendlen_controls();
    $('#pairendedInput').change(maybe_show_pairendlen_controls);
40

    /*
    * Toggle organism input type
    */
45

    $('#org_type_radio').click(function(event) {
        if ($(event.target).hasClass("title")) {
            // user chose "Title"
            $('#genbankfile-controls').hide();
            $('#org_title-controls').show();
50        } else if ($(event.target).hasClass("file")) {
            // user chose "Genbank File"
            $('#org_title-controls').hide();
            $('#genbankfile-controls').show();
55        } // else
            // what the ...
    });
    $('#org_type_radio .title').click();

60    /*

```

```

    * Organism input autocompletion
    */

    var organisms = new Array();

65
    $.ajax({
        url: "rest/organisms",
        dataType: "json",
        success: function(data) {
70
            // No idea yet what to do with those that have multiple
            // accessions listed in 'genome' -- filter them out here for now
            //
            // see ftp://ftp.ncbi.nih.gov/genomes/GENOME_REPORTS/prokaryotes.txt
            //
75
            _(data).each(function(org) {
                if (org.acc.indexOf(",") >= 0)
                    return;
                organisms.push("{} ({} / {})".format(
                    org.title, org.db, org.acc)); }); },
80
    });

    $('#organismInput').typeahead({
        source: organisms,
    });

85
    /*
    * plupload -- from src/plupload/examples/custom.html
    */

90
    var uploads = {
        'inputfile': {},
        'genbankfile': {}
    };

95
    var context = function(name) {

        var self = this;

        var options = {
100
            url: 'upload',
            runtimes: 'html5,gears,flash,silverlight,browserplus,html4',
            browse_button: name + '_browse',
            drop_element: name + '_progress',
            multipart_params: { 'type': name,
105
                'session': upload_session },
            flash_swf_url: path_js + '/plupload.flash.swf',
            silverlight_xap_url: path_js + '/plupload.silverlight.xap',
        };

110
        var events = {
            // 'Init': function(up, params) {
            //     $('#' + name + '_progress .filestatus').text(
            //         "Current runtime: " + params.runtime);
            // },

```

```

115         'FilesAdded': function(up, up_files) {
            // remove all other files already present
            // plupload features multiple files in one widget
            // we have two widgets and one name per widget
            up.splice();
120         self.active = true;
            log.debug("FilesAdded", up.files, up_files);
            $('#' + name + '_progress .filestatus').text(
                up_files[0].name +
                ' (' + plupload.formatSize(up_files[0].size) + ')');
125     },
        'UploadComplete': function(up, up_files) {
            self.complete = true;
            for (nam in uploads)
                if (uploads[nam].active)
130                 if (!uploads[nam].complete)
                    return;
            log.debug("UploadComplete", "go");
            $('#create_form').submit();
        },
135        'UploadProgress': function(up, up_file) {
            $('#' + name + '_progress .bar').css(
                "width", up_file.percent + '%');
            // $('#' + name + '_progress .filestatus').text(
            //     up_file.percent + '%');
140    },
    };

    this.active = false;
    this.complete = false;
145

    var up = this.up = new plupload.Uploader(options);

    $('#' + name + '_progress').click(function() {
        $('#' + name + '_browse').click();
150    });

    $('#create_form_submit').click(function() {
        for (nam in uploads)
            if (uploads[nam].active)
155                { up.start(); return false; }
    });

    for (x in events)
        up.bind(x, events[x]);
160

    log.debug("debug");

    up.init();
    };
165

    for (name in uploads)
        uploads[name] = new context(name);
    });

```

```
170 // vim: et:sw=4
```

rnaseqlyze-analysis.js

```
/*
 * RNA-seqlyze 'analysis' view javascript
 */

5 // backbone.js Models
// -----
//
// -> http://backbonejs.org/#Model

10 // The Analysis
window.Analysis = Backbone.Model.extend({
  urlRoot: "../rest/analyses",
  initialize: function () {
    this.files = new DataDirListing();
15    this.files.analysis = this;

    this.stage_logs = new StageLogList();
    this.stage_logs.analysis = this;

20    // "cascade": update files list
    this.bind("change:data_dir_state", function (self) {
      self.files.fetch({add: true});
    });
    // "cascade": update stage_logs
25    this.bind("change:stage_logs_state", function (self) {
      var len = self.stage_logs.size();
      self.stage_logs.fetch({
        add: true,
        // The last stage_log is the current one and updates frequently.
        // It's id stays the same though and which causes backbone.js
30        // to regard it as a duplicate and drop it. But a copy of the
        // ajax response is passed to the success callback. So we pick
        // the changed log text from there and fire a "change" event
        // by set()ting the 'text' attribute of the affected model.
35        success: function (stage_logs, rsp) {
          if (len)
            stage_logs.at(len-1).set('text', rsp[len-1].text);
        },
      });
40    });
  }
});

// log output of one stage
window.StageLog = Backbone.Model.extend({
45  defaults: {
    stage: null,
    text: null,
  },
  idAttribute: "id",
```

```

50 });
    // log output of all stages
    window.StageLogList = Backbone.Collection.extend({
        model: StageLog,
        url: function () {
55             return this.analysis.url() + "/logs";
        },
    });
    // a model for the files
    window.DataDirFile = Backbone.Model.extend({
60         defaults: {
            path: null,
        },
        idAttribute: "path",
    });
65 // and for a collection of files
    window.DataDirListing = Backbone.Collection.extend({
        model: DataDirFile,
        url: function () {
            return this.analysis.url() + "/files";
70         },
    });

    // note1:
    //
75 // Concerning the above code:
    // It might have been simpler to work the files list right into the
    // analysis model on the server and stick to one model here.
    // But then again, there is no harm in doing it like this, because
    // now the files list is more independent and could for
80 // example also be displayed on a page of its own.

    /* note2:
    *
85 * In the code below,
    *
    * "el"                is defined in rnaseqlyze.js as "$.el", which is defined
    *                    in laconic.js - see http://joestelmach.github.com/laconic/
    *
90 * "this.$el"
    * "this.el"           are the view's (jQuery wrapped) DOM element in the
    *                    backbone.js architecture - see http://backbonejs.org/#View-el
    *
    * "render().el"       is also the view's "el" and works because we always
95 *                    "return this;" from render() - see http://backbonejs.org/#View-render
    */

    // Two Views showing different details about the analysis
    // -----
100 // These render the "Processing" and "Results" section on the
    // analysis page. The Processing view is displayed above the Results view.
    //

```

```

// -> http://backbonejs.org/#View
105
// The "Processing" section
window.ProcessingView = Backbone.View.extend({

  initialize: function () {
110      this.model.bind("change", this.change, this);
      this.stage_logs = (
          new StageLogListView({model: this.model.stage_logs}).render().el);
  },
  change: function (model, value, options) {
115
      // just re-render the whole thing for now
      this.$el.empty();
      this.render();

120
      // remove the busy indicator when finished
      if (model.get('finished'))
          $('#spinner').remove();

      // make scrollspy refresh it's coordinates
      // because the page size has likely changed
125
      $(window).scrollspy('refresh');
  },
  render: function () {
      // toJSON doesn't really do much besides turning
      // the model.attributes into a useable object
      // see http://backbonejs.org/#Model-toJSON
130
      var analysis = this.model.toJSON();

      this.$el.append(
135
          el.h2("Processing")
      );

      this.$el.append(el.div(
          el.h3("Input Check")
140
          ,
          analysis.inputfile_uploaded ?
              el.p("Type of input: ",
                  analysis.inputfile_type ?
                      el.strong(analysis.inputfile_type) :
145
                      el.span("not detected"))
              :
              null
          ,
          analysis.inputfile_header ?
150
              el.p("First read in input data: ",
                  el.pre(analysis.inputfile_header))
              :
              null
          ));

155
      this.$el.append(el.div(

```



```

        el.h3("Stage Logs")
    ,
    this.stage_logs
  ));

  if (analysis.error)
    this.$el.append(
      el.div({class: "alert alert-error"},
        el.h4({class: "alert-heading"},
          "An error occured while analyzing the data"),
          analysis.error));

  return this;
},
});

// The monospaced stage log blocks
175 window.StageLogListView = Backbone.View.extend({
  initialize: function () {
    this.model.bind("add", this.add, this);
    if (!this.model.analysis.get('finished')) {
      this.model.analysis.bind("change:finished",
180         this.analysis_change, this);
    }
  },
  analysis_change: function (model, value, options) {
    if (value) {
185      this.$el.contents().find("pre")
        .last().css('background-color', '');
    }
  },
  add: function (model) {
190    this.$el.append(
      new StageLogView({model: model}).render().el
    );
    if (!this.model.analysis.get('finished')) {
      this.$el.contents().find("pre")
        .not(':last').css('background-color', '')
        .prevObject.last().css('background-color', '#ddf');
      this.$el.contents().last().scrollTopBottom();
    }
    $(window).scrollspy('refresh');
200  },
});

// _One_ monospaced stage log block
window.StageLogView = Backbone.View.extend({
205  initialize: function () {
    this.model.bind("change", this.change, this);
  },
  change: function (model, options) {
    this.$el.children("pre").text(model.get('text'));
    this.$el.scrollTopBottom();
210    $(window).scrollspy('refresh');
  }
});

```

```

    },
    render: function () {
        var log = this.model.toJSON();
215         this.$el.attr('id', log.stage);
        this.$el.append(el.h4(log.stage));
        this.$el.append(el.pre(log.text));
        return this;
    },
220 });

// The "Results" section
window.ResultsView = Backbone.View.extend({
    initialize: function () {
225         this.model.bind("change", this.change, this);
        this.model.files.bind("add", this.fileadd, this);
    },
    change: function (model, value, options) {
230         this.$el.empty();
        this.render();
        $(window).scrollspy('refresh');
    },
    fileadd: function () {
        var augmented_gb = this.model.files.find(function (file) {
235             return file.get('path').match(/augmented\.gb$/);
        });
        if (!this.augmented_gb) {
            this.augmented_gb = augmented_gb;
            this.$el.empty();
240             this.render();
        }
    },
    render: function () {
        var analysis = this.model.toJSON();
245         if (analysis.hg_url || this.augmented_gb) {
            this.$el.append(el.h2("Results"));
            var $ul = $(el.ul())
            this.$el.append($ul[0]);
            if (this.augmented_gb) {
250                 var href = _id + '/files/' + this.augmented_gb.get('path');
                $ul.append(el.li(
                    el.a({href: href},
                        "Augmented Genbank File")));
            }
255             if (analysis.hg_url) {
                $ul.append(el.li(
                    el.a({href: analysis.hg_url},
                        "Link to custom tracks in UCSC browser"),
                    el.p("It might take a minute until the tracks become " +
260                        "available.", el.br(),
                        "As soon as the last few items ",
                        el.a({href: galaxy_history_url}, "here"),
                        " turn green it should work."));
            }
265         }
    }

```

```

        return this;
    },
});

270 // A View displaying the list of files associated with
// this analysis available on the server (log files, mostly).
// This is currently rendered inside the "Processing" section above.
window.DataDirView = Backbone.View.extend({
    initialize: function () {
275         this.model.bind("reset", this.reset, this);
        this.model.bind("add", this.add, this);
    },
    reset: function (model, value, options) {
280         this.$el.empty();
        this.render();
    },
    render: function () {
        this.$el.append(el.h2("Data Directory"));
        var ul = el.ul();
285         this.$ul = $(ul);
        this.$el.append(ul);
        $(window).scrollspy('refresh');
        return this;
    },
    add: function(model) {
290         this.$ul.append(
            new DataDirFileView({model: model}).render().el
        );
        $(window).scrollspy('refresh');
295     },
});
// An View, that renders one file
window.DataDirFileView = Backbone.View.extend({
    el: "<li>",
300     render: function (model) {
        var file = this.model.toJSON();
        var href = _id + '/files/' + file.path;
        this.$el.html(el.a({href: href}, file.path));
        return this;
305     }
});

// Initialization
310 // -----

$(document).ready(function () {

    // the id of the displayed analysis
315     _id = _(window.location.pathname.split('/')).last();

    // create a backbone.js Model
    // with an associated Collection
    analysis = new Analysis({

```

```

320     id: _id,
    });

    // create two backbone.js views for the
    // analysis, render and insert them into the DOM
325    $('#processing').html(
        new ProcessingView({model: analysis}).render().el
    );
    $('#results').html(
        new ResultsView({model: analysis}).render().el
330    );
    $('#datadir').html(
        new DataDirView({model: analysis.files}).render().el
    );

335    /*
    // uncomment this to see what's going on in backbone.js
    if (rnaseqlyze_debug) {
        analysis.bind("all", function (event) {
            log.debug("analysis", arguments);
340        });
        analysis.files.bind("all", function (event) {
            log.debug("analysis.files", arguments);
        });
        analysis.stage_logs.bind("all", function (event) {
345            log.debug("analysis.stage_logs", arguments);
        });
    }
    */

350    // update the models until the analysis is finished
    var update = function () {
        // check at the beginning and not at the end
        // because the fetch() calls are asynchronous
        if (analysis.attributes.finished)
355            return;
        analysis.fetch();
        // log.debug("analysis.fetch()");
        window.setTimeout(update, 7000); // re-update in 7 seconds
    }
360    update();
    });

```


3.2 Software Requirement Specification

RNA-Seqlyze

Software Requirement Specification

Professor:
Prof. Dr. Georg Lipps

Student:
Patrick Pfeifer

Bachelor Thesis

Appendix II

Version	Author	Comment	Date
0.1	Patrick Pfeifer	Document created	25. Mai 2012
0.2	Patrick Pfeifer	fix some wordings	30. Mai 2012
0.3	Patrick Pfeifer	Remove Glossary	13. Juli 2012

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1 - Introduction

1 Introduction**1.1 Purpose**

This document details the software requirements specification for the RNA-Seqlyze next-generation RNA-sequencing analysis software. It defines the intended use of the software and lists the required features.

1.2 Project Scope

The RNA-Seqlyze web application is the main product of the RNA-Seqlyze free software project. The project was started by Patrick Pfeifer as part of his bachelor thesis at the University of Applied Sciences and Arts Northwestern Switzerland FHNW at the School of Life Sciences.

RNA-seq data is of increasing importance to the analysis of prokaryotes. The intended use of this software is to aid researchers in analyzing data generated by next-generation RNA sequencing methods (RNA-seq). Specifically, the software is supposed to improve the annotation of existing genome data.

1.3 Intended Audience and Structure of this Document

All parties involved in the project may refer to this document as the definite source of information concerning it.

Software users will generally be most interested in chapters number two and three. They contain information regarding the available features, with detailed descriptions of the expected in- and outputs.

Developers planning to contribute code are strongly encouraged to read chapter four as well, as it contains important information about the reliability-, performance- and interface-requirements and -standards that must be fulfilled.

1.4 References

This document is written in adherence to the *IEEE Recommended Practice for Software Requirements Specifications*:

- IEEE Std 830-1998
<http://standards.ieee.org/findstds/standard/830-1998.html>

2 Overall Description**2.1 Product Environment**

RNA-seq - the application of next-generation deep sequencing methods to DNA transcripts - carries the potential to deliver new insights into the organization and functionality of an organism's genome.

To achieve this, the large amounts of data produced by one of the various next generation sequencing (NGS) platforms available on the market, have to be analyzed in detail. Short reads of only a few dozen base pairs (bp) have to be mapped to a reference genome. The total number of reads mapped at each position in

3 - System Features

the genome is counted to produce a transcript coverage "signal". The more more reads, the stronger, roughly, the gene is expressed in the organism.

2.2 Product Features

The envisioned web application is supposed to automate the process of analyzing the data generated by NGS platforms deployed for RNA-seq experiments with prokaryotes. The data will be made available to the application in FASTQ or SRA format. In case SAM/BAM or coverage data files have already been produced, they can be made available to the application as well.

The RNA-Seqlyze software processes this data using a custom-made algorithm. It generates a list of transcribed sequences and assigns a confidence score to each of those regions. The score will be computed based on the provided input data as well as various other relevant information relating to the studied organism. This auxiliary data incorporated into the processing algorithms has been collected beforehand and is readily available to the application. Specifically, the application will include predictions for shine-dalgarno sequences, rho-independent terminators, operons (polycistronic transcripts) and, optionally, promoter sites.

2.3 User Characteristics

It is assumed that a researcher using the application has basic IT-skills and is used to interacting with popular computer interfaces. The handling of the the RNA-Seqlyze web application shall be easy for him.

He has a good understanding of the technology applied to generate the data that he wishes to analyze. A fair amount of specialized knowledge and fluency with the most popular technical terms *will be required* to use the application in an efficient manner.

3 System Features

3.1 Priorities

The priorities are assigned by the client and have the following meanings:

high	This feature is indispensable and absolutely necessary for the correct functioning of the product. It must be implemented.
medium	This feature is not indispensable but makes a substantial contribution to the usability of the product. It should be implemented.
low	This feature contributes towards a better usability of the product but it is not a strictly necessity. The functionality would be nice to have.

3.2 RNA-seq Data Analysis

Description and Priority

TBD

Priority: **high**

4 - Nonfunctional Requirements

Functional Requirements

TBD

3.3 Custom Track Generation

Description and Priority

TBD

Priority: medium

Functional Requirements

TBD

4 Nonfunctional Requirements

4.1 Quality Requirements

4.1.1 Documentation

The source code shall be documented, such that modifications or additional modules could be integrated by third-party developers. Furthermore, an extensive user manual shall be composed.

4.1.2 Usability

The application's user interface shall be easy to use and follow current conventions. When using the software, the user shall constantly be informed what the current state of the application is, which steps have been already carried out and which ones are to be carried out next.

4.1.3 Reliability and Maintainability

An error-free execution of all functions of the software shall be achieved by writing tests for all parts (unit tests) as well as for the whole system (integration tests). The coverage of the unit tests shall reach at least 80 Percent of the source code.

In case the server hosting the application is rebooted, the application shall be automatically restarted as well.

4.1.4 Performance and Efficiency

Load times and data transmission shall be within reasonable bounds. Except for the transmission of big data files from the users PC to the application server, there shall be no significant delays when using the application.

The time required to process a given dataset shall be estimated and the estimate shall be presented to the user before he triggers the processing by clicking the designated button.

4 - Nonfunctional Requirements

4.1.5 Security

The data transmitted to the application for processing is not expected to be privacy-sensitive or confidential. Data submitted by individual users will generally not be presented to other users, but no efforts are made to protect the data from being retrieved by other authorized users of the server.

3.3 Glossar

RNA-seq	Next-generation Sequenzierungs-Technologie angewendet auf das Profiling kompletter Transkripte
Object Relational Mapper	Ein Programmbibliothek, die automatisch die von einer Software verwendeten <i>Business-</i> bzw. <i>Domain-</i> Objekte in einer Datenbank persistiert.

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