BioSignalML

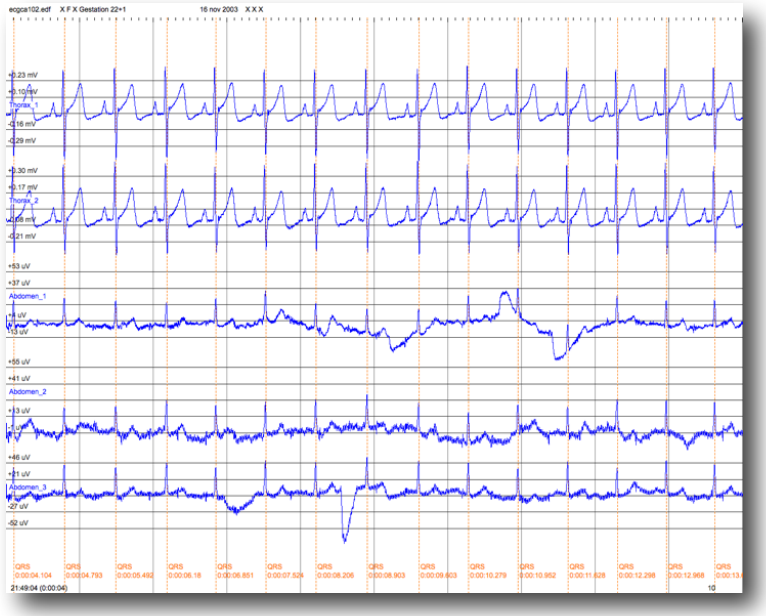
Putting biosignals onto the Semantic Web

David Brooks

AUCKLAND BIOENGINEERING INSTITUTE
THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Background

- Biosignal -- time series data resulting from a biological process.



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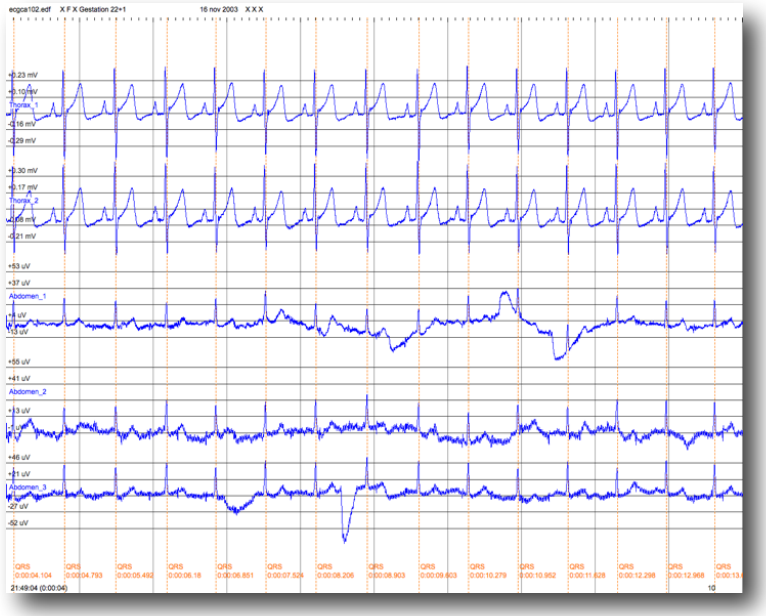
- Sampled, usually at a regular rate, which is usually much greater than the highest frequency of interest.



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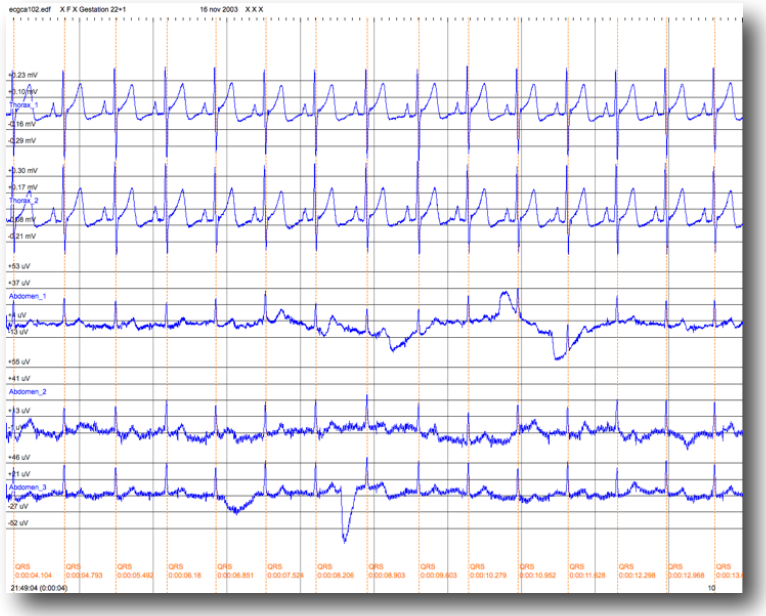

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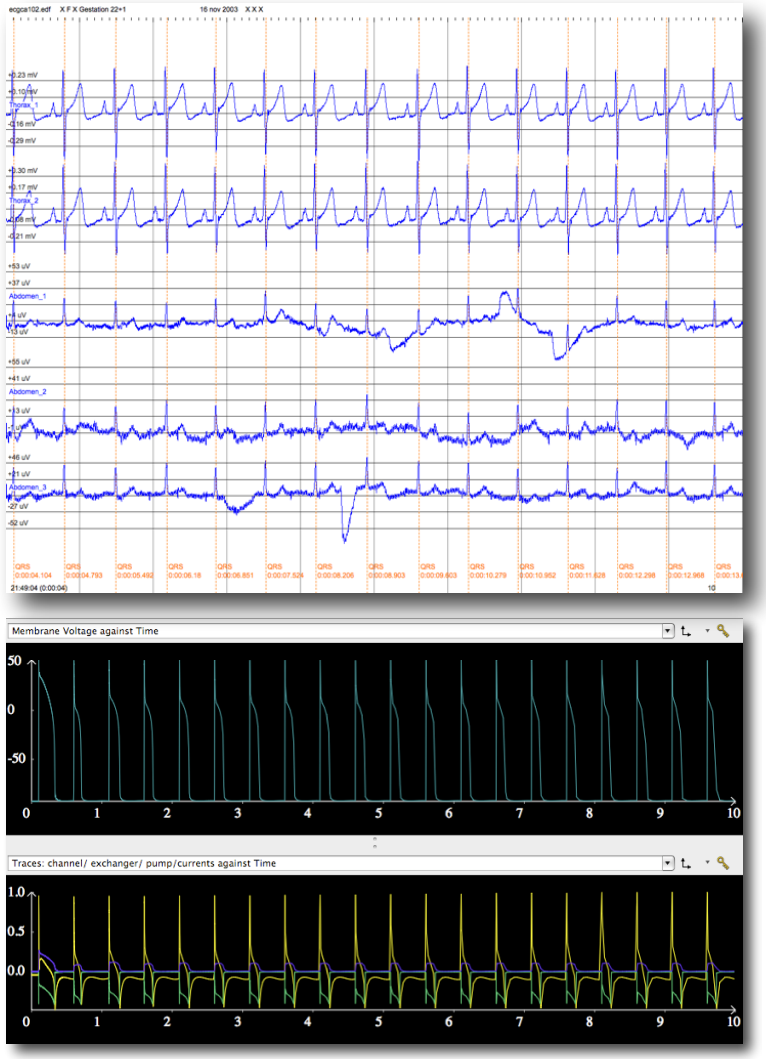
- Simulation time series data.



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- A lot of file formats:
  - manufacturer; research; regulatory; …

BDF	24 bit version of EDF
EDF	European Data Format
EDF+	European Data Format plus
FDAXML	FDA standard for ECG
GDF	General Data Format (an EDF derivative)
MFER	Medical waveform Format Encoding Rules (ISO)
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- Metadata content tends to be domain specific.

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- Polysomnography:
  - *“Currently, digital data from most PSG systems can only be viewed if one utilizes the system with which it was collected.”* [1]
  - *“Unfortunately, not much has happened since … no consensus for data sharing has taken root.”* [2]

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  - Units: μV, uV, $V \times 10^{-6}$??

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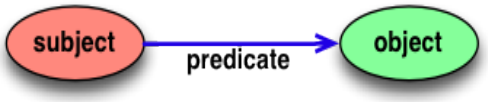
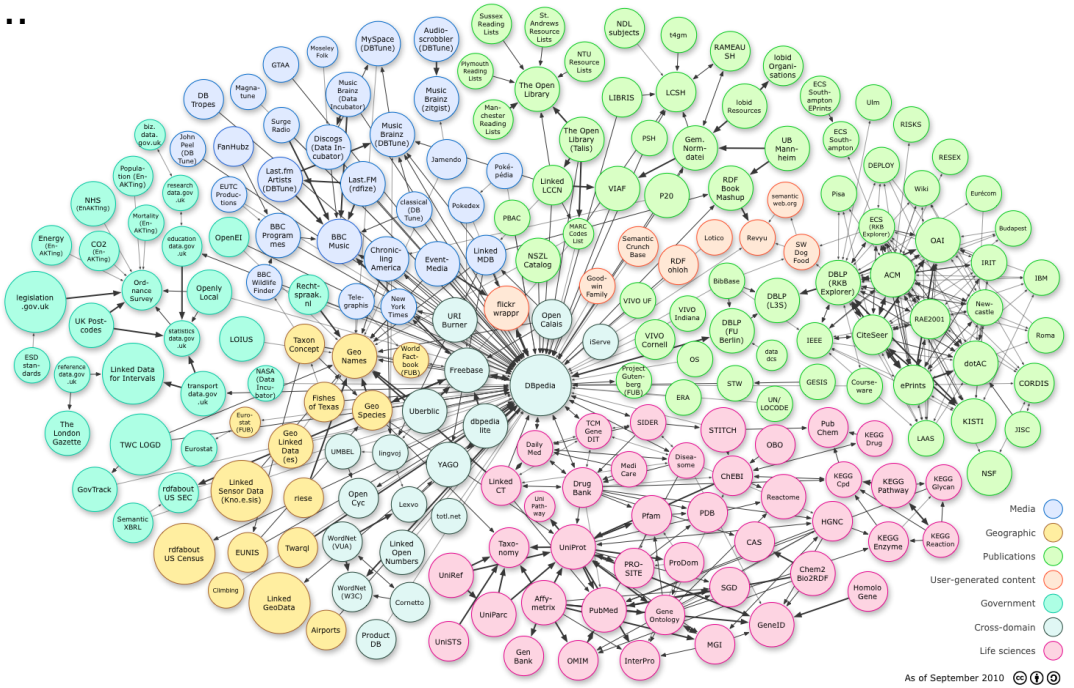
- Linking Open Data





Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. http://lod-cloud.net/

BioSignalML

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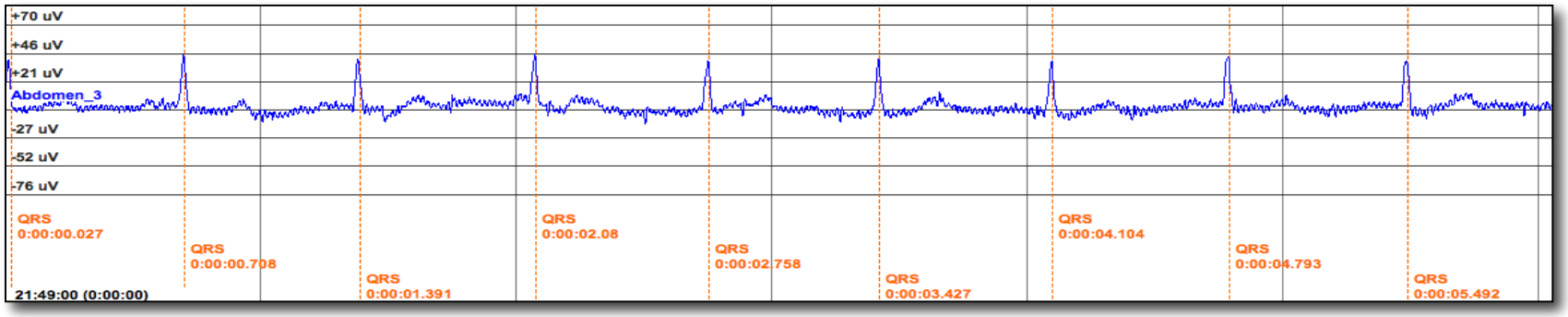
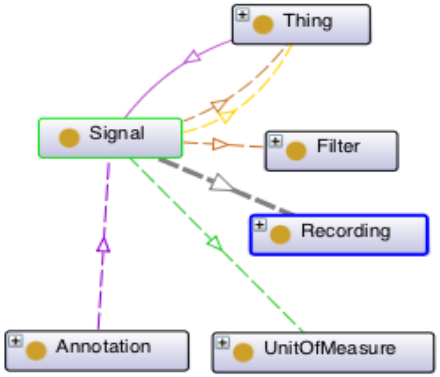
  - Ontologies define terms, properties, relationships.
- Time series data is in native format; everything else is available as RDF metadata.

http://repository.biosignal.org/recording3/signal/4



BioSignalML as RDF

- Core concepts:
  - Recordings
  - Signals
  - Events and Annotations.



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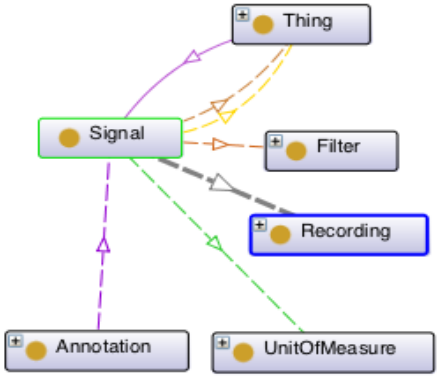
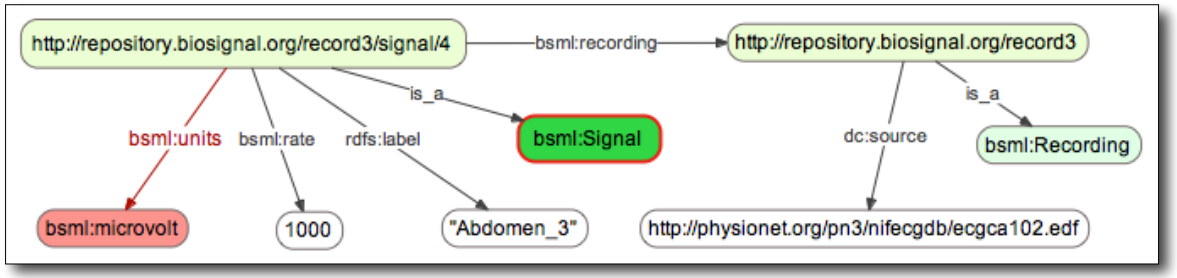
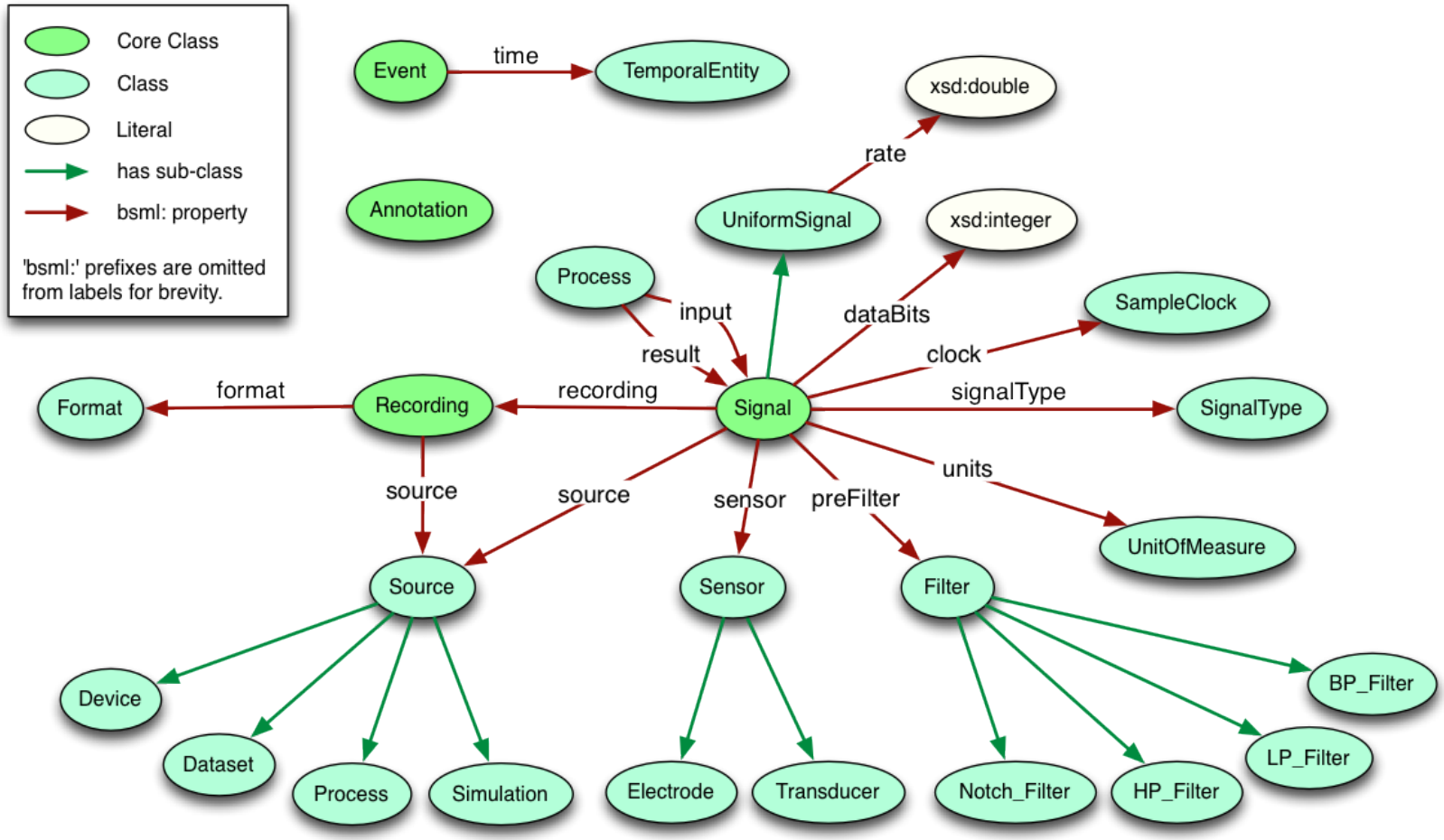


- RDF graph:



BioSignalML as an ontology

- Classes, terms, properties, relationships:



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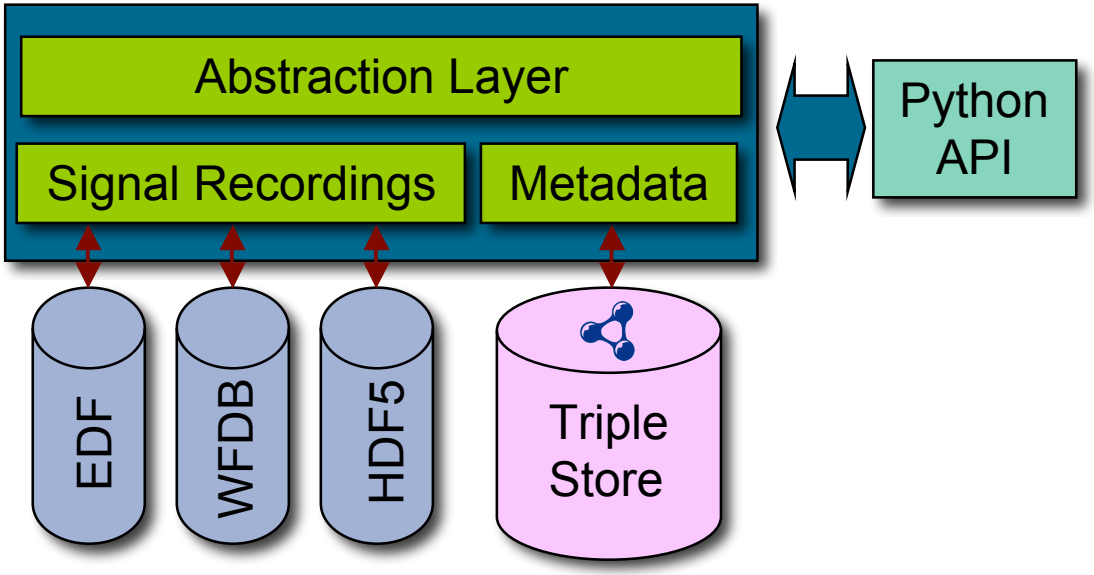
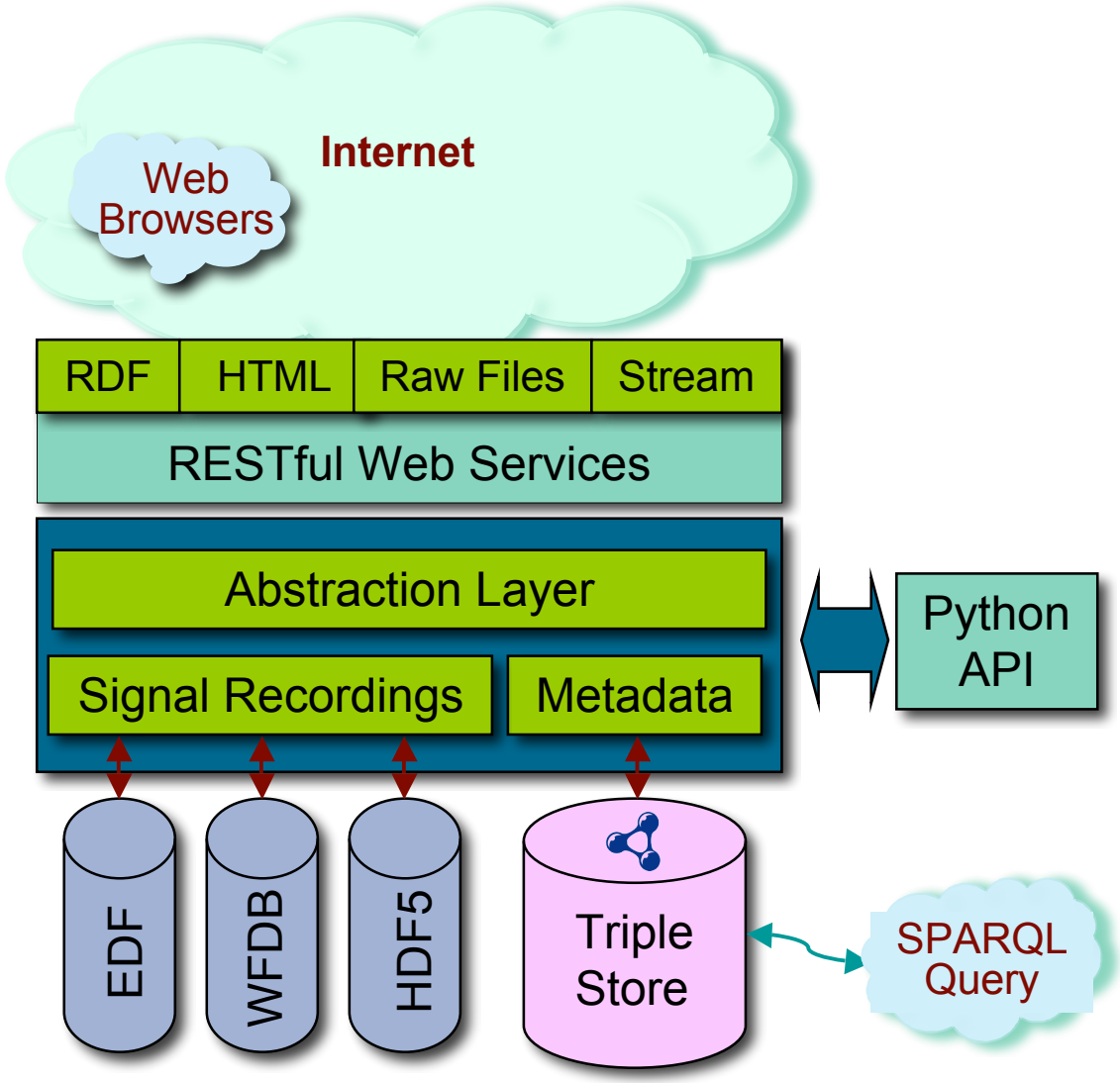


BioSignalML implementation

- Biosignal repository:
- Web based with HTTP endpoints:
  - File import/export
  - RDF metadata
  - Data streamed via web-sockets.



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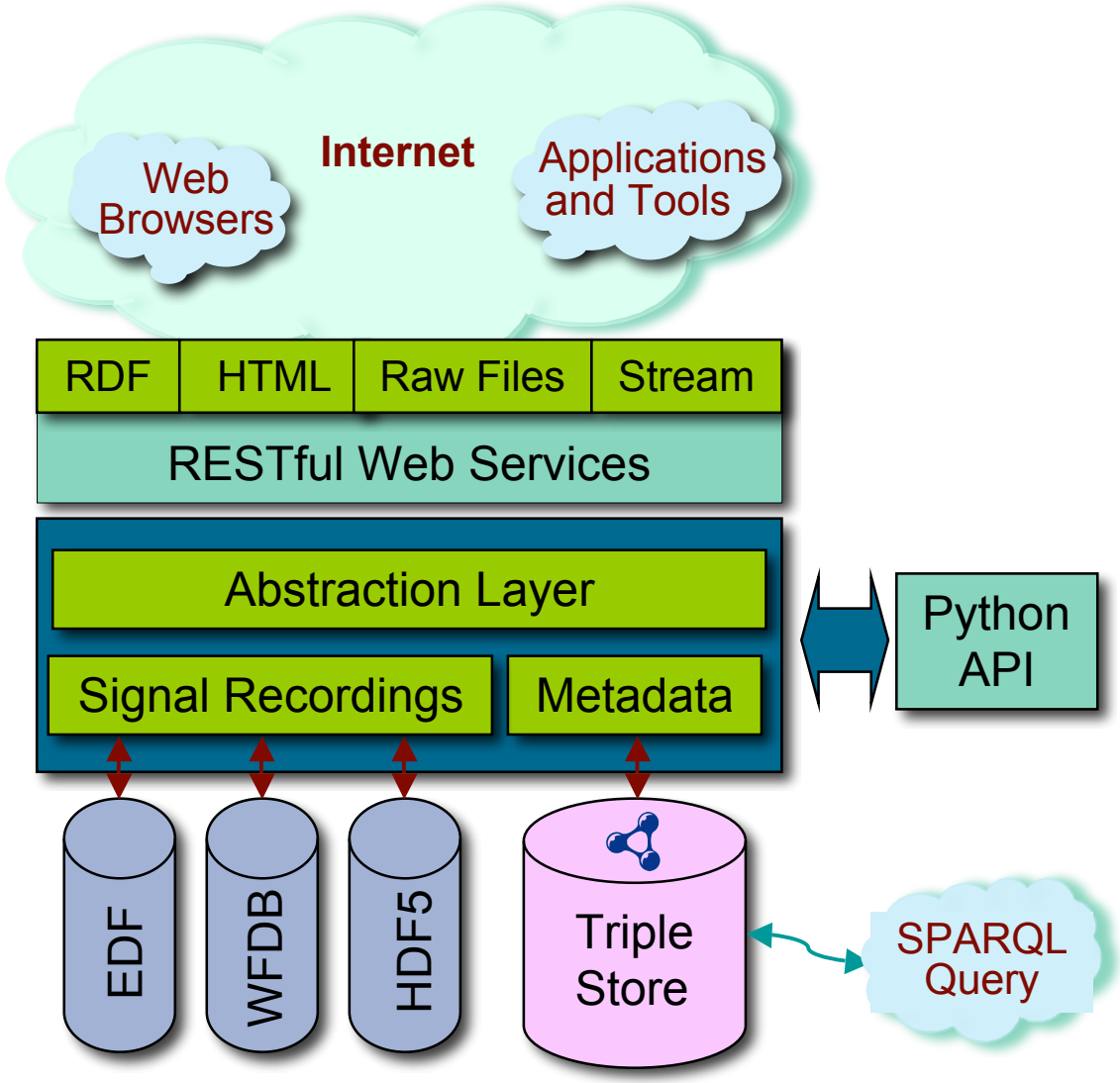
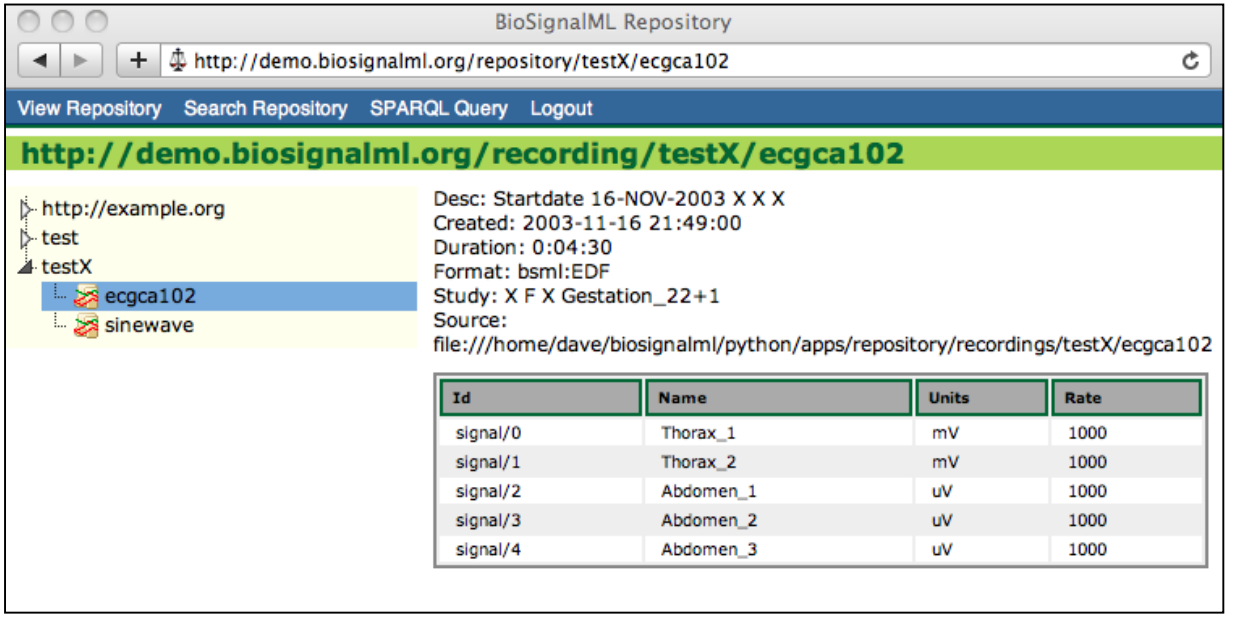
- C client (plus Python, Javascript, …)



BioSignalML clients

- Web browser:



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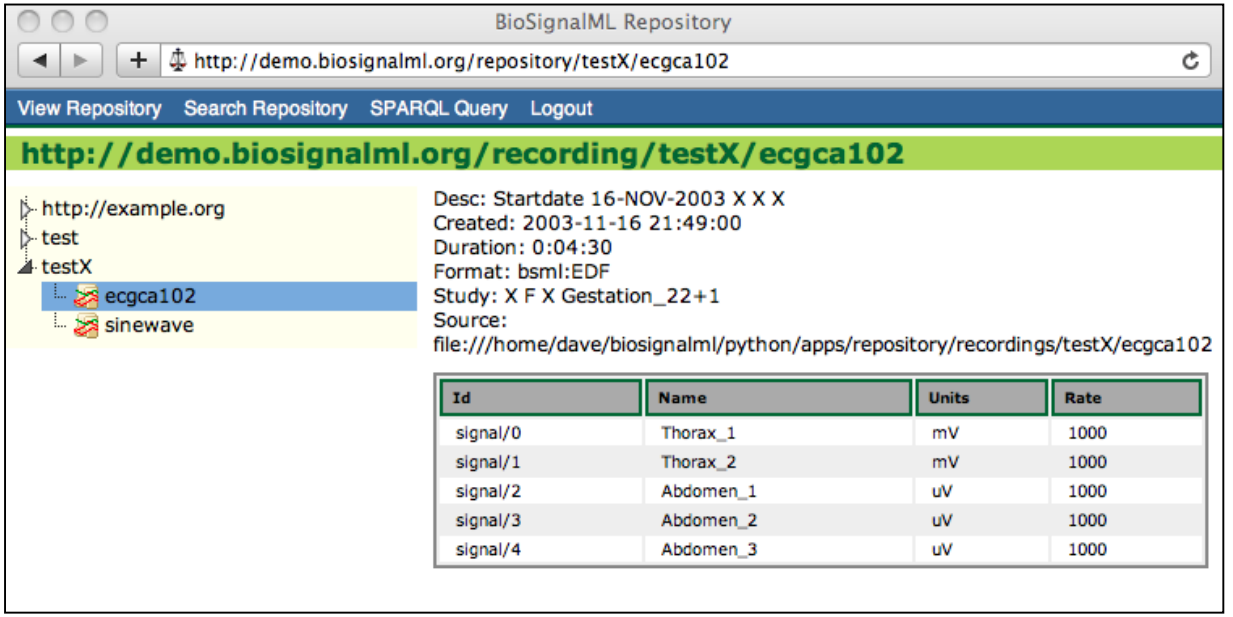

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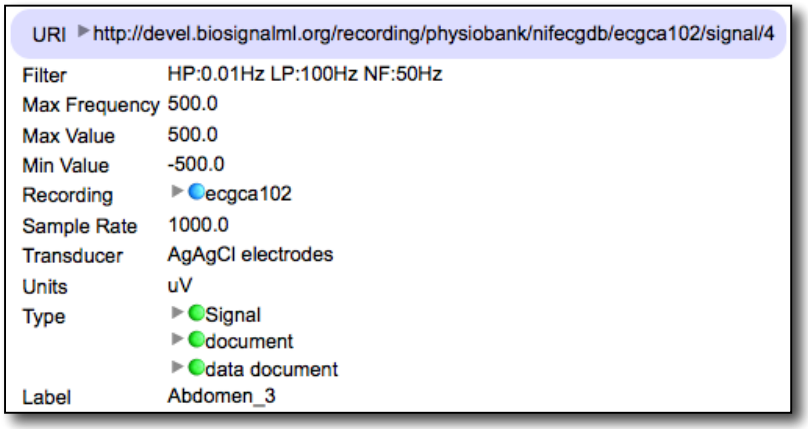

BioSignalML clients

- Python code:

```
import biosignalml
import biosignalml.units as units


repo = biosignalml.Repository('http://demo.biosignalml.org')
rec = repo.new_recording('http://example.org/recording/test')
sig = rec.new_signal(id='a1', units=units.millivolt)
for data in datasource:
  sig.append(data)
rec.close()


sig = repo.get_signal('http://example.org/recording/test/signal/a1')
print sig.uri, sig.label, sig.units

start = 0.0
end = 10.0
duration = 1.0
while start < end:
  interval = sig.recording.interval(start, duration)
  for data in sig.read(interval):
    print data  # SignalSegment
  start += duration
```

BioSignalML clients

- CellML modelling:

```
<model name="bwfilter" cmeta:id="bwfilter" xmlns="http://www.cellml.org/cellml/
   <component name="filter">
      <variable cmeta:id="time" name="t" units="second"/>
      <variable cmeta:id="input" name="v_i" units="volt" initial_value="0"/>
      <variable cmeta:id="output" name="v_o" units="volt"/>
      <variable name="R" units="ohm" initial_value="1"/>
      <variable name="C" units="farad" initial_value="1.333333"/>
      <variable name="L1" units="henry" initial_value="1.5"/>
      <variable name="L2" units="henry" initial_value="0.5"/>
      <variable name="v_c" units="volt" initial_value="0"/>
      <variable name="i_1" units="ampere" initial_value="0"/>
      <variable name="i_2" units="ampere" initial_value="0"/>
      <math xmlns="http://www.w3.org/1998/Math/MathML">
         <apply>
            <eq/>
            <ci>v_o</ci>
            <apply>
               <times/>
               <ci>i_2</ci>
               <ci>R</ci>
            </apply>
         </apply>
         <apply>
            <eq/>
            <apply>
               <diff/>
               <bvar>
                  <ci>t</ci>
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$ ./bwfilter http://devel.biosignalml.org/recording/physiobank/nifecgdb/ecgca102/signal/3
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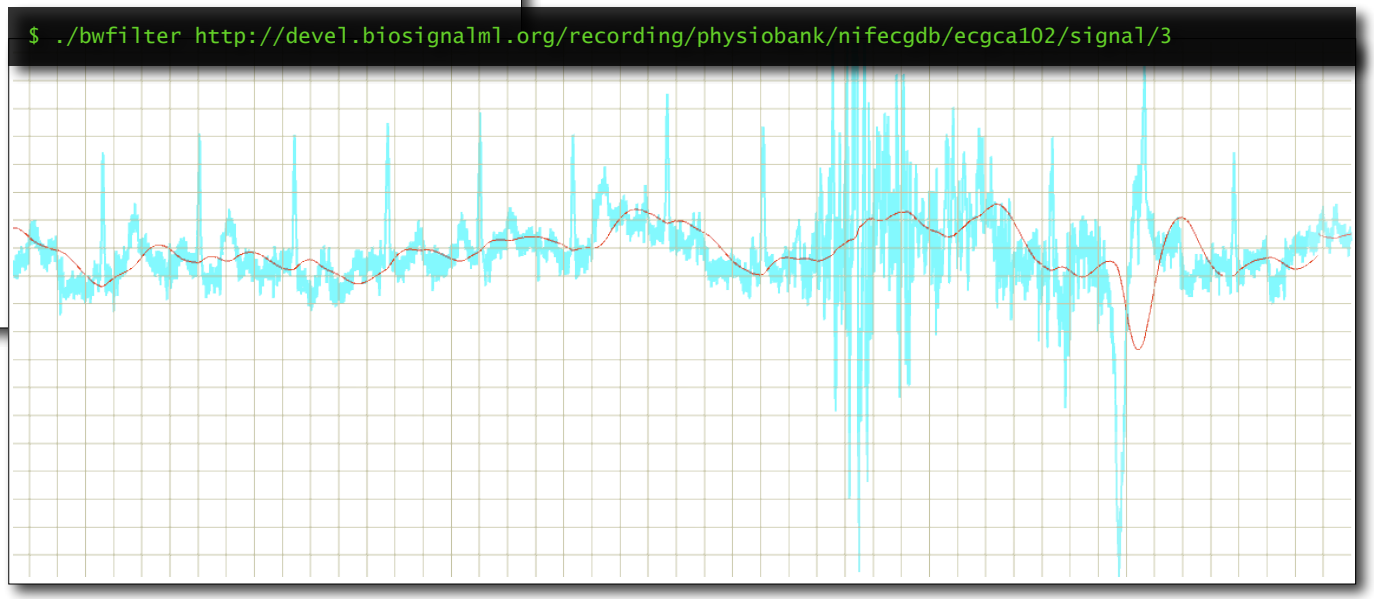

Ongoing work

- Interfacing with simulation tools (OpenCOR, SED/ML)
  - real world applications.
- Adding a Semantic Web layer to PhysioBank.
- Integrate Units of Measurement Expressions:
  - http://www.sbpax.org/uome/index.html
  - Ontology to derive units from other units.
  - An extensible way to automate units validation and conversion.

Thank you