

CWM

Closed World Machine



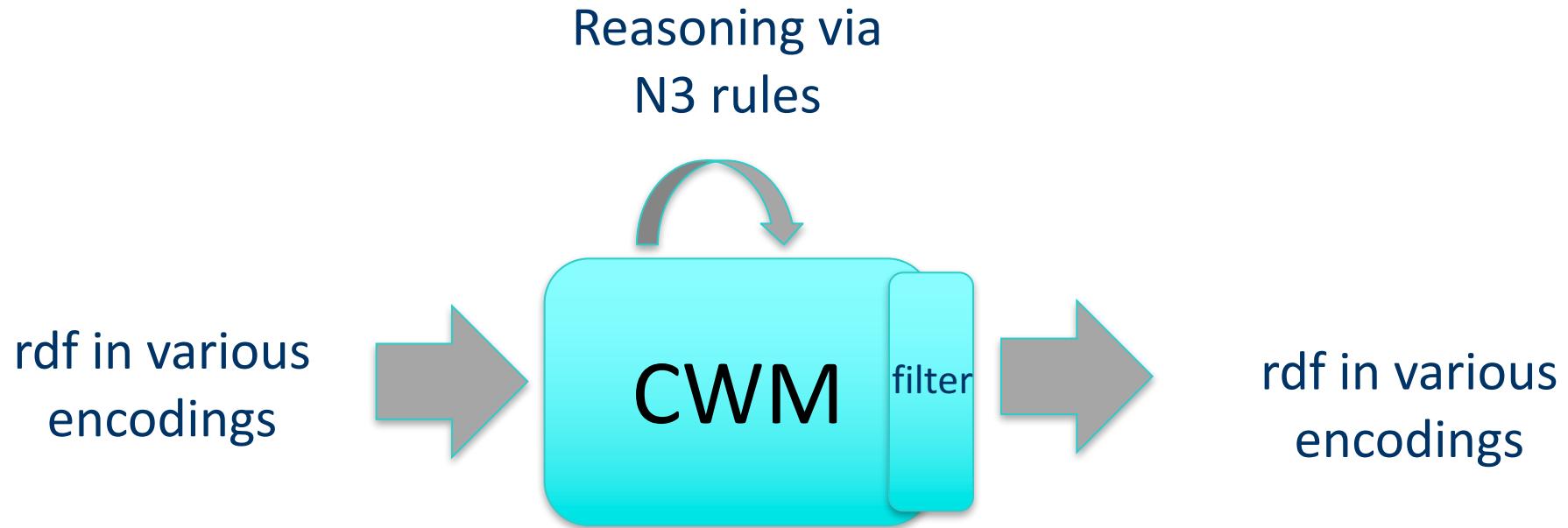
CWM Overview

- CWM is a simple Semantic Web program that can do the following tasks
 - Read and pretty-print several RDF formats
 - Store triples in a queryable triples database
 - Perform inferences via forward chaining rules
 - Perform builtin functions such as comparing strings, retrieving resources, all using an extensible builtins suite
- CWM was written in Python by Tim Berners-Lee and Dan Connolly of the W3C

What's CWM good for?

- CWM is good for experimenting with RDF and RDFS and some OWL
- CWM's rule based reasoner can't cover all of OWL
- A good Unix command line tool
- rdfs:seeAlso
 - <http://infomesh.net/2001/cwm/>
 - <http://w3.org/2000/10/swap/doc/Processing>

CWM in a Nutshell



CWM command line

- Example: `cwm --rdf foo.rdf --n3 > foo.n3`
- Args are processed left to right (except for flags
--pipe and –help)
- Here's what happens:
 - Switch to RDF/XML input-output format
 - Read in `foo.rdf` (use a filename or URI) and add triples to store
 - Switch to `--n3` input-output format
 - Output triples in store to `stdout` in N3
 - Unix redirect captures output in `foo.n3`

On N3 and Turtle

- N3 notation was invented by Tim Berners Lee
- Not a standard, but a large subset, [Turtle](#), is
- What's in N3 but not in Turtle
 - Representing inference rules over RDF triples
 - A compact syntax for reification
 - Some other bits
- The rules part is most useful
 - Supplanted by SWRL and SPARQL
 - And by RIF (Rule Interchange Formalism)

Reasoning using N3 Rules

- N3 has a simple notation for [Prolog](#) like rules
- These are represented in RDF, of course, and can read these into CWM just like a data file
- Command line args tell CWM to reason
 - apply=foo : read rules from foo, apply to store, adding conclusions to store
 - rules : apply once the rules in the store to the store, adding conclusions to the store
 - filter=foo : apply rules in foo to the store, REPLACING the store with the conclusions
 - think : apply rules in store to the store, adding conclusions to the store, iteratively until no more new conclusions are made

N3 facts and rules

- :Pat owl:sameAs :Patrick .
- :Man rdfs:subClassOf :Human .
:YoungMan rdfs:subClassOf :Man .
- :has_father rdfs:domain :Human; rdfs:range :Man .
:Sara :has_father :Alan .
- { ?x :has_parent ?y } => { ?y :has_child ?x } .
- {?x :has_parent ?y. ?y :has_brother ?z}
=> {?x :has_uncle ?z} .
- { :thermostat :temp ?x. ?x math:greaterThan "70" }
=> { :cooling :power "high" } .

Implications in logic

- In logic, an implication is a sentence that is either *true* or *false*
 - $\forall x \text{ man}(x) \Rightarrow \text{mortal}(x)$
- Of course, we may not know if it's true or false
- If we believe an implication is true, we can use it to derive new true sentences from others we believe true
 - *man(socrates)* therefore *mortal(socrates)*
- This is the basis for rule based reasoning systems
 - Prolog, Datalog, Jess, etc.

Quantifiers

- In classical logic, we have two quantifiers, forall (\forall) and exists (\exists)
 - $\forall x \exists y \text{ has_child}(x, y) \Rightarrow \text{is_parent}(x)$
 - For all x , if there exists a y such that x *has_child* y , then x is a parent, or in other words
 - X is a parent if X has (at least) one child
 - You only need find **one** child to conclude that someone is a parent
- Variables (e.g., x and y) range over all *objects* in the universe, but for KB systems, we can narrow this to objects mentioned in the KB

Variables in rules implicitly quantified

- Most rule-based systems don't use explicit quantifiers
- Variables are *implicitly* quantified as either \forall or \exists , typically using the following scheme:
 - Variables in rule conclusion are *universally* quantified
 - Variables appearing *only* in premise are *existentially* quantified
- $\text{has_child}(p,c) \Rightarrow \text{isa_parent}(p)$ interpreted as
 $\forall p \exists c \text{ has_child}(p,c) \Rightarrow \text{isa_parent}(p)$

Variables in rules implicitly quantified

- To see why this is a reasonable design decision for a rule language, consider

$$\forall x \forall y \text{ has_child}(x, y) \Rightarrow \text{isa_parent}(x)$$

- What does this mean?

X is a parent if we can prove that X has *every object* in our universe as a child

- Such rules are not often useful
- Many rule languages do have ways to express them, of course

Reasoning: Forward and Backward

- Rule based systems tend to use one of two reasoning strategies (and some do both)
 - Reasoning *forward* from known facts to new ones (find all people who are parents; is Bob among them?)
 - Reasoning *backward* from a conclusion posed as a query to see if it is true (Is Bob a parent?)
- Each has advantages and disadvantages which may effect its utility in a given use case
- CWM uses a forward reasoning strategy
 - We often want to compute all RDF triples that follow from a given set (i.e., find the *deductive closure*)

N3 Rules: premis => conclusion

- An N3 rule has a *conjunction* of triples as a premise and a *conjunction* as a conclusion
- E.g.: 2nd element of a triple is always a property
 $\{ ?S ?P ?O. \} \Rightarrow \{ ?P \text{ a rdf:Property. } \}$
- E.g.: Meaning of rdfs:domain
 $\{ ?S ?P ?O. ?P \text{ rdfs:domain } ?D. \} \Rightarrow \{ ?S \text{ a } ?D. \}$
- Variables begin with a ?.
- Variable in conclusions must appear in premise
- Each way to instantiate triples in the premise with a set of KB triples yields new facts

Note: limited negation & disjunction

- What about disjunction, aka OR?
 - You're a parent if you have a son **or** a daughter
- Disjunction in the premise can be achieved using several rules
 - $\{ ?S :has_son ?O. \} \Rightarrow \{ ?S :has_child ?O. \}$
 - $\{ ?S :has_daughter ?O. \} \Rightarrow \{ ?S :has_child ?O. \}$
- No disjunction allowed in conclusion
 - Allowing this requires a much more complex proof algorithm
 - “When you have eliminated the impossible, whatever remains, however improbable, must be the truth”

Note: limited negation & disjunction

- No general logical negation is provided
 - This is common in rule based systems, e.g., Prolog
- Negation and disjunction supported in other ways in OWL and RIF and in other reasoners

N3 rules use cases

- Use N3 rules to implement the semantics of RDF, RDFS, and OWL vocabularies
 - See [rdfs-rules.n3](#)
 - See [owl-rules.n3](#)
- Use N3 rules to provide domain/application specific rules
 - See [gedcom-relations.n3](#)

A simple example

```
% more simple1.n3
```

```
# A simple example
```

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
```

```
@prefix : <#> .
```

```
:john a foaf:Person;
```

```
    foaf:name "John Smith";
```

```
    foaf:gender "Male";
```

```
    foaf:name "John Smith" .
```

Invoking CWM (1)

```
% cwm simple1.n3
```

```
# Processed by Id: cwm.py,v 1.197 2007/12/13 15:38:39 syosi Exp  
# using base file:///Users/finin/Sites/691s13/examples/n3/simple1.n3  
# Notation3 generation by notation3.py,v 1.200 2007/12/11 21:18:08 syosi  
Exp
```

```
# Base was: file:///Users/finin/Sites/691s13/examples/n3/simple1.n3
```

```
@prefix : <#> .
```

```
:john a <http://xmlns.com/foaf/0.1/Person>;  
<http://xmlns.com/foaf/0.1/gender> "Male";  
<http://xmlns.com/foaf/0.1/name> "John Smith" .
```

```
#ENDS
```

Invoking CWM (2)

```
n3> cwm -n3=/d simple1.n3
```

```
# Processed by Id: cwm.py,v 1.197 2007/12/13 15:38:39 syosi Exp
# using base file:///Users/finin/Sites/691s13/examples/n3/simple1.n3
# Notation3 generation by notation3.py,v 1.200 2007/12/11 21:18:08 syosi Exp
# Base was: file:///Users/finin/Sites/691s13/examples/n3/simple1.n3
```

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
```

```
<#john>    a foaf:Person;
            foaf:gender "Male";
            foaf:name "John Smith" .
```

Some useful CWM flags

- CWM command has a lot of flags and switches
- Do cwm --help to see them
- Here are a few

--rdf Input & Output ** in RDF/XML instead of n3 from now on
--n3 Input & Output in N3 from now on. (Default)
--n3=flags Input & Output in N3 and set N3 flags
--ntriples Input & Output in NTriples (equiv --n3=usbpertane -bySubject -quiet)
--apply=foo Read rules from foo, apply to store, adding conclusions to store
--think as -rules but continue until no more rule matches (or forever!)
--think=foo as -apply=foo but continue until no more rule matches (or forever!)
--data Remove all except plain RDF triples (formulae, forAll, etc)
--help print this message

RDFS in N3 (1)

@prefix rdf: <<http://www.w3.org/1999/02/22-rdf-syntax-ns#>>.

@prefix rdfs: <<http://www.w3.org/2000/01/rdf-schema#>>.

@prefix owl: <<http://www.w3.org/2002/07/owl#>>.

...

rdfs:comment rdfs:domain rdfs:Resource; rdfs:range rdfs:Literal.

rdfs:domain rdfs:domain rdf:Property; rdfs:range rdfs:Class.

rdfs:label rdfs:domain rdfs:Resource; rdfs:range rdfs:Literal.

rdfs:range rdfs:domain rdf:Property; rdfs:range rdfs:Class.

rdfs:seeAlso rdfs:domain rdfs:Resource; rdfs:range rdfs:Resource.

rdfs:subClassOf rdfs:domain rdfs:Class; rdfs:range rdfs:Class.

rdfs:subPropertyOf rdfs:domain rdf:Property; rdfs:range rdf:Property.

rdf:type rdfs:domain rdfs:Resource; rdfs:range rdfs:Class.

...

RDFS in N3 (2)

{?S ?P ?O} => {?P a rdf:Property}.

{?S ?P ?O} => {?S a rdfs:Resource}.

{?S ?P ?O} => {?O a rdfs:Resource}.

{?P rdfs:domain ?C. ?S ?P ?O} => {?S a ?C}.

{?P rdfs:range ?C. ?S ?P ?O} => {?O a ?C}.

{?Q rdfs:subPropertyOf ?R. ?P rdfs:subPropertyOf ?Q}
=> {?P rdfs:subPropertyOf ?R}.

{?P rdfs:subPropertyOf ?R. ?S ?P ?O} => {?S ?R ?O}.

{?A rdfs:subClassOf ?B. ?S a ?A} => {?S a ?B}.

{?B rdfs:subClassOf ?C. ?A rdfs:subClassOf ?B}
=> {?A rdfs:subClassOf ?C}.

Demonstration

- Install cwm
- Download files in the n3 examples directory

[http://cs.umbc.edu/courses/graduate/691/fall
17/01/examples/n3/](http://cs.umbc.edu/courses/graduate/691/fall17/01/examples/n3/)

HW3

UMBC CMSC 491/691 The Se +
VPN | www.csee.umbc.edu/courses/graduate/691/fall17/01/hw/hw3/

UMBC CMSC 491/691 Fall 2017

A Web of Data

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Draft HW Three Draft

Experimenting with RDFS using N3

Due before midnight on Wednesday, 23 October 2017

N3 is a notation for RDF that is easier for people to read and write than XML/RDF. N3 also supports a simple syntax for rules that allows us to define rules to implement the meaning of RDF and (most of) OWL as well as other domain specific reasoning over RDF data. Turtle is a simplified, RDF-only subset of N3 that is a W3C recommendation.

CWM is a simple reasoner implemented in Python that you can use to experiment with both N3 and reasoning over RDF content. You can [download and install cwm](#) on your own computer or use it on the gl linux systems. CWM is a python program, so you may need to install python if you are running Windows. On gl, you can use the version I have installed in my files. Adding one of the following to your .cshrc (if your shell is tcsh) or .bashrc (for bash).

```
for csh and tcsh: alias cwm "/afs/umbc.edu/users/f/i/finin/pub/cwm"
```

Summary

- CWM is a relatively simple program that lets you manipulate and explore RDF and Semantic Web technology
- It's limited in what it can do and not very efficient
- But useful and “close to the machine”
- Written in Python
- There are related tools in Python, see [rdflib](#)
- And lots more tools in other languages

genesis

```
# A simple example of family relations using  
the gedcom vocabulary.
```

```
@prefix gc:  
  <http://www.daml.org/2001/01/gedcom/  
  gedcom#>.
```

```
@prefix log:  
  <http://www.w3.org/2000/10/swap/log#  
  >.
```

```
@prefix owl:  
  <http://www.w3.org/2002/07/owl#>.
```

```
@prefix : <#> .
```

```
# data from the Bible in GEDCOM form  
:fam1 a gc:Family.
```

```
:Able gc:sex gc:Male;  
gc:givenName "Able";  
gc:childIn :fam1;  
owl:differentFrom :Cain.
```

```
:Cain gc:sex gc:Male;  
gc:givenName "Cain";  
gc:childIn :fam1;  
owl:differentFrom :Able.
```

```
:Adam gc:sex gc:Male;  
gc:givenName "Adam";  
gc:spouseIn :fam1;  
owl:differentFrom :Eve.
```

```
:Eve gc:sex gc:Female;  
gc:givenName "Eve";  
gc:spouseIn :fam1;  
owl:differentFrom
```