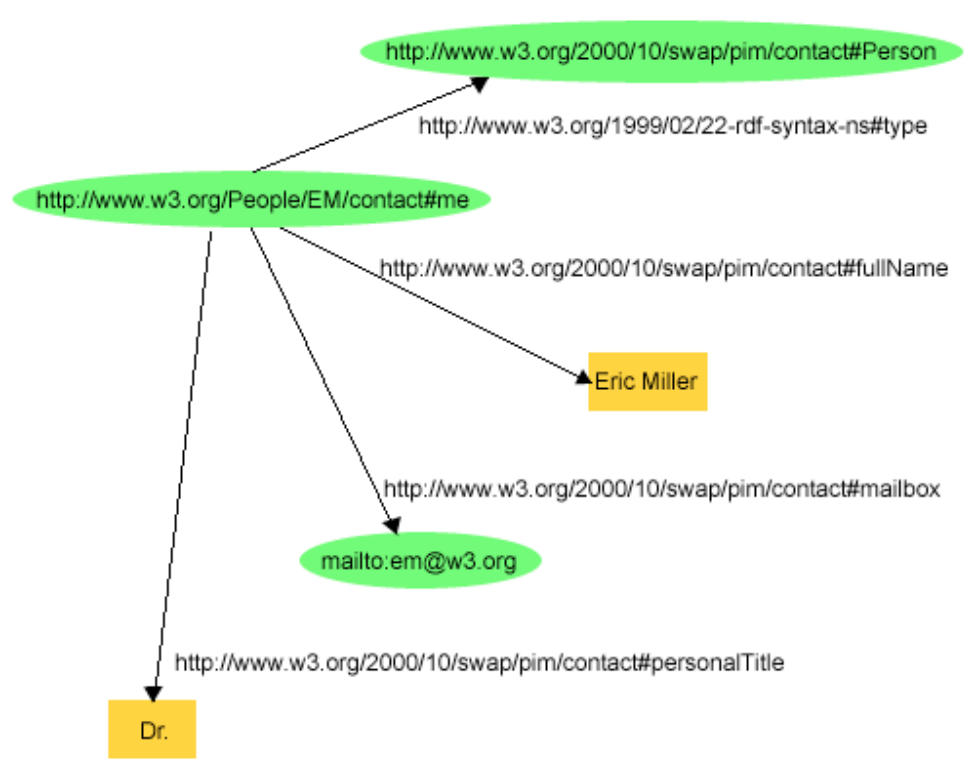
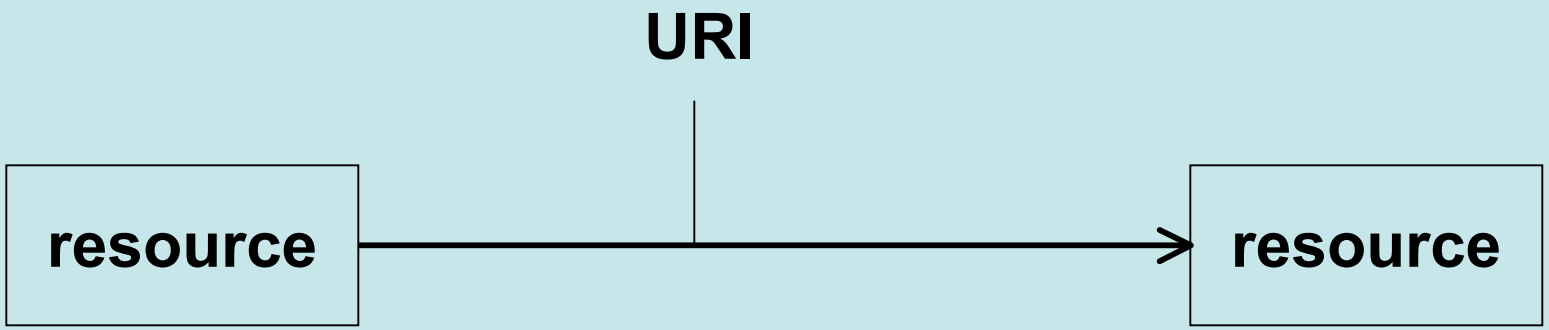
RDF - next step



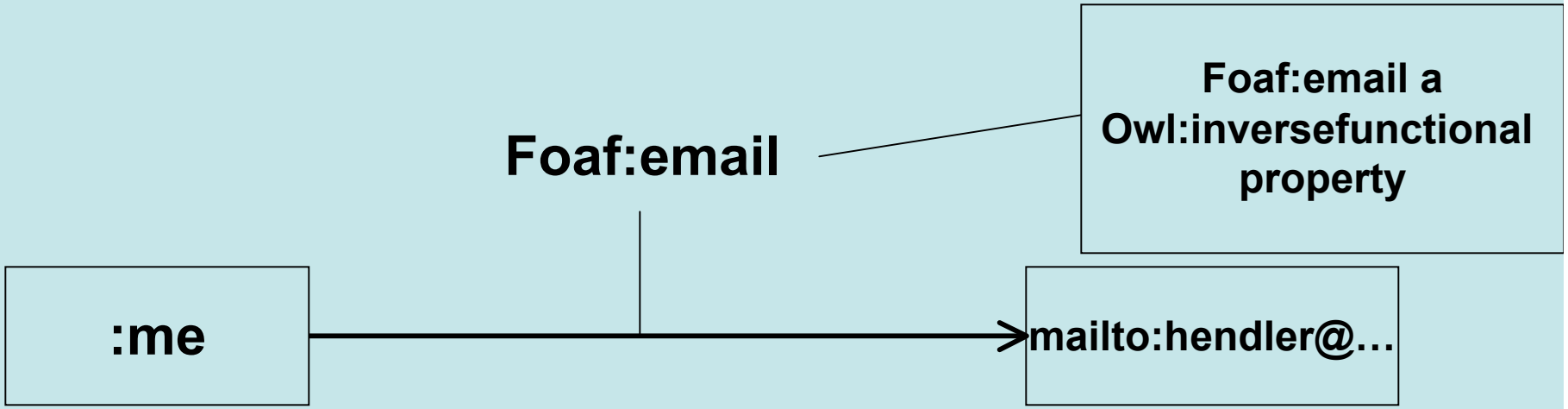
URIs for the relations is important
- **common naming (RDF)**
- **dereferencing! (RDFS, OWL)**

Adding the Semantics



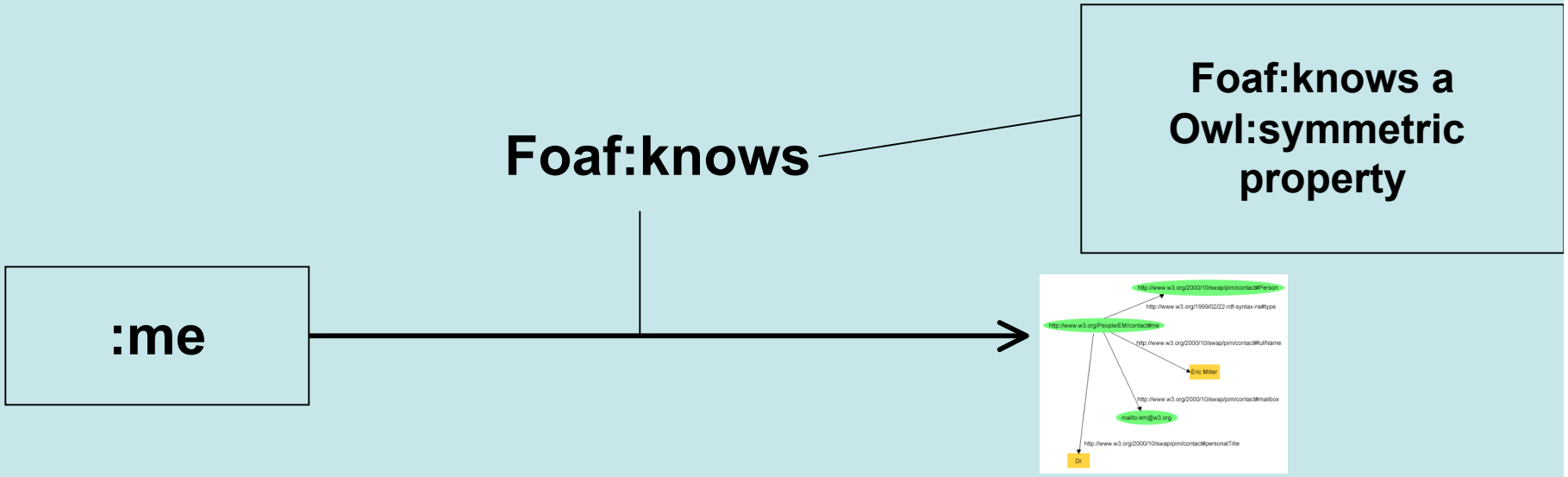
- This is an RDF "Triple" (resources can also be URIs)
- Make the URI dereferencible for a machine-readable description
  - That is, put the ontology at that URI!
  - RDFS and OWL are basically XML dialects for this

Adding the **Semantics**



- Ex: Asserts that email address is a many to one relation (i.e. different people with same email address will be considered equivalent)
  - Can merge multiple FOAF files describing same user from different applications

Adding the Semantics



- RDFS and OWL provide other property restrictions as well
  - Which are properties needed for data modeling, domain vocabularies, etc.
- This is the heart of the Semantic Web
  - Why we talk links, not documents

Why?

- Semantics allows inferencing
  - RDFS allows domain, range mapping
    - :sister a rdfs:class;
      rdfs:range foaf:person;
      rdfs:domain ex:female.
  - OWL adds
    - Property inferencing
      - Symmetric, transitive, 1-1, 1-many, many-1
      - (similar to Entity-Relationshop Modeling)
    - "restricted" Class inferencing
      - The mother of a kitten is a cat (but not all mothers are cats)
      - Cardinality (a baseball team has 9 in the lineup…)
    - Some mapping relations
      - US-sport:soccer owl:sameAs UK-sport:football

Reasoners

- Procedural
  - A special purpose piece of code "doing the right thing"
    - RDFS, some subset of OWL
- Rule-based
  - Map constructs to rules
    - RDFS, many subsets of OWL (almost OWL Lite)
    - Non-OWL applications (cf. CWM& N3 rules)
- Special purpose
  - Subset of FOL optimized for decidable subset
    - OWL DL
- General
  - Full FOL reasoner
    - Beyond OWL

RDF Schema

- (Almost named RDF Vocab Def. Lang)
  - Some archival documents say RDF VDL
    - Luckily it stopped there
  - Graphs => Semantic networks
    - Class, subClassOf, property, subPropertyof, domain and range
    - BUT for the web (URIs!)
      - Also datatypes and literals
  - Also some usability stuff
    - label, comment
      - Defined to be strings with internationalization

RDFS example

http://home.fhtw-berlin.de/~engelh/div/hamster.rdfs

Intro to OWL (ca. 2003)

http://www.w3.org/2003/Talks/0522-webont-hendler/

OWL

- W3C Recommendation
- xmlns:owl="http://www.w3.org/2002/07/owl#"
- Successor to DAML+OIL
- Three Species
  - OWL Lite
  - OWL DL
  - OWL Full

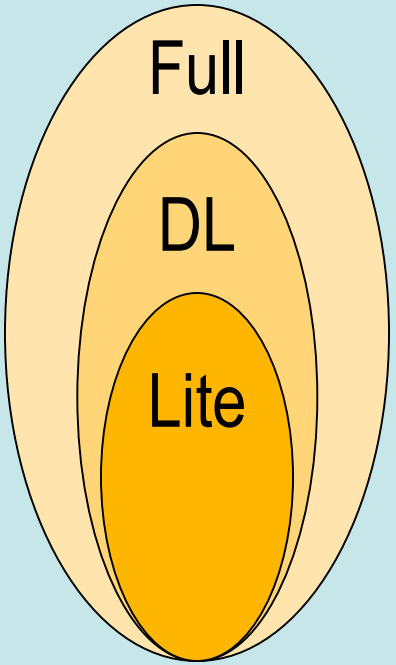
Language Layers

OWL Light

- (sub)classes, individuals
- (sub)properties, domain, range
- conjunction

RDF Schema

- (in)equality
- cardinality 0/1
- datatypes
- inverse, transitive, symmetric
- hasValue
- someValuesFrom
- allValuesFrom



OWL DL

- Negation
- Disjunction
- Full Cardinality
- Enumerated types

OWL Full

- Allow meta-classes etc

OWL Lite Features

Equality

- equivalentClass
- equivalentProperty
- sameAs
- differentFrom
- allDifferent

Example

- ZipCode equivalentClass PostalCode
- If zip code and postal code are supposed to be different - e.g. zip is for american addresses and postal is for foreign ones - then we can say they are different
- ZipCode differentFrom PostalCode

```
<owl:Class rdf:ID="ZipCode">
    <owl:differentFrom
    rdf:resource="http://example.com/ont.owl#PostalCode/>
</owl:Class>
```

Property Characteristics

- inverseOf
  - hasParent is the inverseOf hasChild
- TransitiveProperty
  - E.g. - ancestorOf - if Bob is an ancestorOf Joe and Joe is an ancestorOf Fred, then Bob is an ancestorOf Fred
- SymmetricProperty
  - E.g. if Tom is marriedTo Michelle, then Michelle is marriedTo Tom
- FunctionalProperty (unique value)
  - Wine hasMaker - hasMaker is functional (there can be only one)
- InverseFunctionalProperty
  - The inverse of a functional property - makesWine is the inverse of hasMaker and is an inverseFunctionalProperty

Restrictions

- Property Type Restrictions
  - allValuesFrom
    - The hasMother property has allValuesFrom the class Woman
  - someValuesFrom
    - The hasChild property has someValuesFrom the class Woman
- Restricted Cardinality (can be 0 or 1 in Lite)
  - minCardinality
  - maxCardinality
  - Cardinality

Local Restrictions on Property Ranges

- Instead of setting **a** range for a property, each class can have its own range
- E.g. The range of eats for vegetarians is different than for non-vegetarians
- Done with subclasses and a restriction

```
<owl:Class rdf:ID="Vegetarian">
    <rdfs:subClassOf>
        <owl:Restriction>
          <owl:onProperty rdf:resource="#eats"/>
          <owl:allValuesFrom rdf:resource="#VegetarianFood"/>

        </owl:Restriction>
    </rdfs:subClassOf>
    …
```

Versioning

- versionInfo
- priorVersion
- backwardCompatibleWith
- inCompatibleWith
- DeprecatedClass
- DeprecatedProperty

OWL DL and Full

Class Axioms

- one of
  - An enumeration of instances
  - E.g. fromContinent must have a value that is one of the following: Antarctica, N. America, S. America, Africa, Europe, Asia, Australia
- hasValue
  - A property must have a specific instance of a value
  - E.g. a U.S. Citizen's citizenOf property is restricted to have the value USA

Combinations

- unionOf (uses ParseType)
  - E.g. European Union Citizenship is the unionOf the citizenship of the member states
- intersectionOf (uses ParseType)
  - E.g. Fire engines are found in the intersection of RedThings and Trucks
- complementOf (used like subClassOf)
  - E.g. the complementOf livingThings are all things that are non-living
- disjointWith (used like subClassOf)
  - E.g. Man and Woman are disjoint classes

```
<owl:Class rdf:ID="Man"/>
<owl:Class rdf:ID="Woman">
      <owl:disjointWith rdf:resource="#Man"/>
</owl:Class>
```

Intersection Example

```
<owl:Class>
    <owl:intersectionOf rdf:parseType="Collection">
        <owl:Class>
            <owl:equivalentClass
rdf:resource="http://www.ksl.stanford.edu/projects/DAML/UNSPSC.daml#F
    ood-Beverage-and-Tobacco-Products"/>
        </owl:Class>

        <owl:Class>
            <owl:equivalentClass
rdf:resource="http://www.ksl.stanford.edu/projects/DAML/UNSPSC.daml#M
    eat"/>
        </owl:Class>
    </owl:intersectionOf>
</owl:Class>
```

ComplementOf Example

```
<owl:Class>
    <owl:complementOf>
        <owl:Class>
            <owl:intersectionOf rdf:parseType="Collection">
                <owl:Class>
                    <owl:equivalentClass
rdf:resource=”#Food"/>
                </owl:Class>

                <owl:Class>
                    <owl:equivalentClass
rdf:resource="#Meat"/>
                </owl:Class>
            </owl:intersectionOf>
        </owl:Class>
    </owl:complementOf>
</owl:Class>
```

Cardinality

- Cardinality restrictions without limits

Emerging Language

- A subset of OWL that is
  - Tractable
  - Easier syntactically
  - Easily mapped to rules
  - "understandable"
  - Powerful enough to be useful
- Sometimes called "RDFS+" or "OWL Mini"
  - Owl Fast, Owl Prime, Owl Ultralite, OWLET

Owl Mini

Vocabulary Comparison Matrix	Current proposal	Oracle's ISWC	OWL Lite
RDF Schema Features:			
* Class (Thing, Nothing)	yes	yes	yes
* rdfs:subClassOf	yes	yes	yes
* rdf:Property	yes	yes	yes
* rdfs:subPropertyOf	yes	yes	yes
* rdfs:domain	yes	yes	yes
* rdfs:range	yes	yes	yes
* Individual	yes	yes	yes
"Annotation" Properties:			
* rdfs:label	yes	yes	yes
* rdfs:comment	yes	yes	yes
* rdfs:seeAlso	yes	yes	yes
* rdfs:isDefinedBy	yes	yes	yes
ADD FROM OWL			
(In)Equality:			
* equivalentClass	yes	yes	yes
* equivalentProperty	yes	yes	yes
* sameAs	yes	yes	yes
* differentFrom	?	yes	yes
Property Characteristics:			
* inverseOf	yes	yes	yes
* TransitiveProperty	yes	yes	yes
* SymmetricProperty	yes	yes	yes
* FunctionalProperty	yes	yes	yes
* InverseFunctionalProperty	yes	yes	yes
* AnnotationProperty	no	yes	yes
MAYBE:			
* AllDifferent, distinctMembers	?		yes
* ObjectProperty	yes	yes	yes
* DatatypeProperty	yes	yes	yes
* disjointWith	?	***yes***	no
Class/Restriction/MISC			
* complementOf	no	***yes****	no
* oneOf	no	no	no
* Restriction	no	no	yes
* allValuesFrom, someValuesFrom	no	no	yes
* minCardinality, maxCardinality	no	no	yes*
* cardinality	no	no	yes*
* unionOf	no	no	no
* intersectionOf	no	no	yes
* hasValue	no	no	no
* DataRange	no	no	no

Note: OWL DL/FULL has everything.

Foaf is pretty close to OWL Mini

Demo:

Browsing FOAF in Swoop

Foaf: http://xmlns.com/foaf/0.1/
Swoop: http://www.mindswap.org/2004/SWOOP/