A Domain Specific Language for Usage Management

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Outline

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Introduction

What motivated us to do this DSL?

- Easier domain representation
- Internal v. External DSL

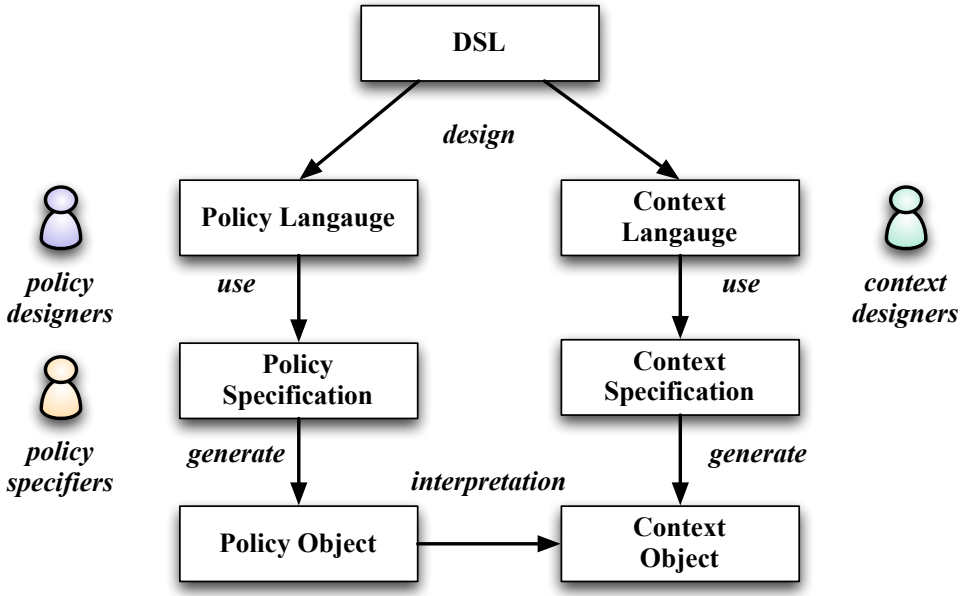
What is motivating our work?

- Applying policy-centric usage management dynamically, incorporating into network fabrics
- Providing attribution and query capabilities to policies and licensure
- Creating dynamic flexible policy environments

We think this DSL will help is in our longer term goals.

Design — Notional Use

Notional Use:



- *DSL* — Domain specific language
- *Policy Language* — Language elements specific to *policy*
- *Context Language* — Language elements specific to *context*
- *Policy Specification* — Actual specification of policy
- *Context Specification* — Specification of context requirements
- *Policy Object* — An object embodying policy created from the DSL
- *Context Object* — An object containing context

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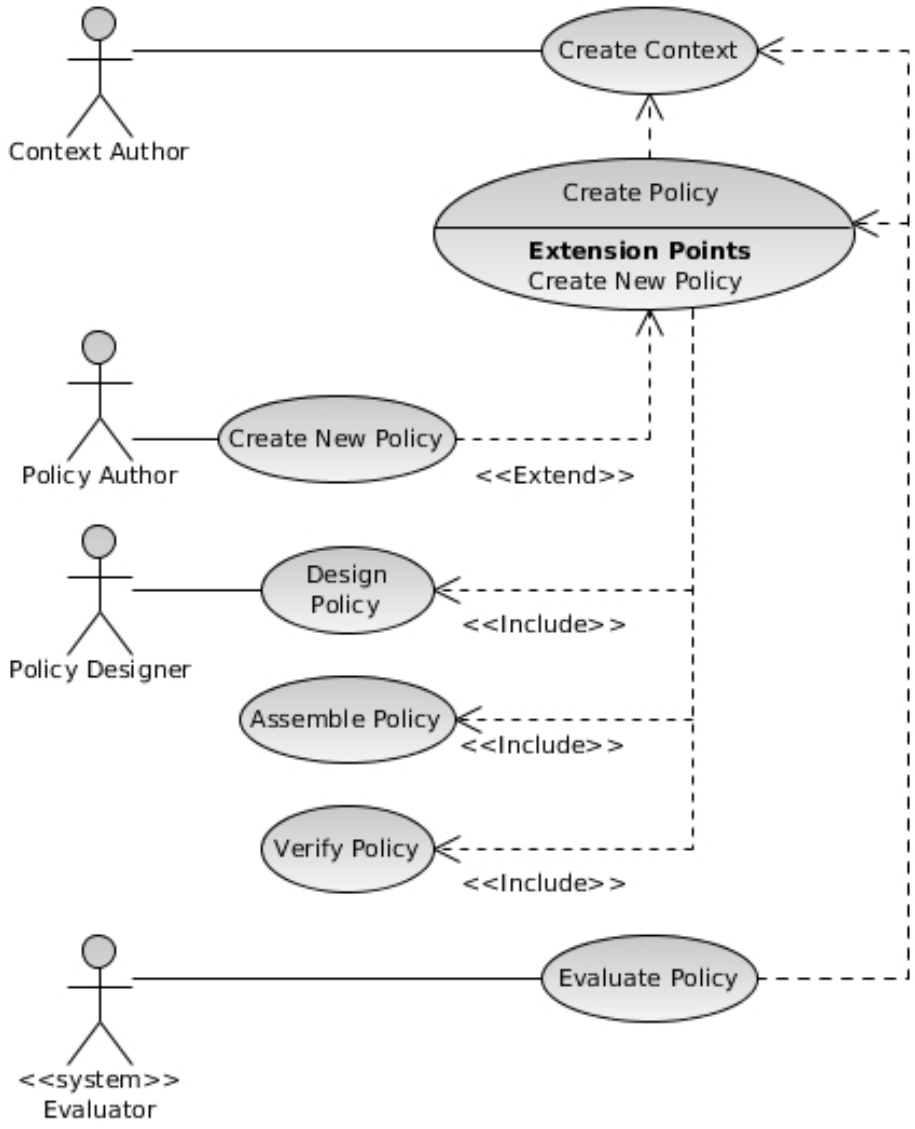
Design — Use Cases

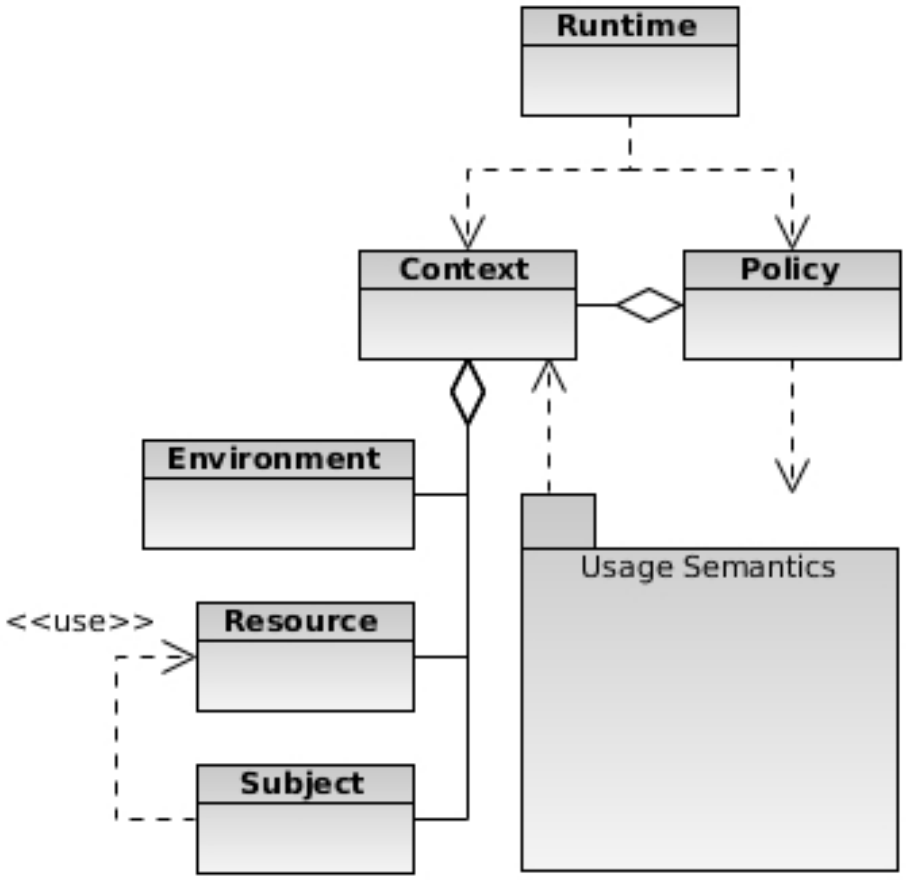
Use Cases:



- *Create Context* — Prior to creating a policy, the context in which that policy will be evaluated must be defined.
- *Create Policy* — A designer creates a new type of policy, embodied by specific extension elements or semantic constraints over existing elements. An author will use these to create an instance of a policy.
- *Evaluate Policy* — The policy is evaluated with a context.

Design — Domain Model

Domain Model:



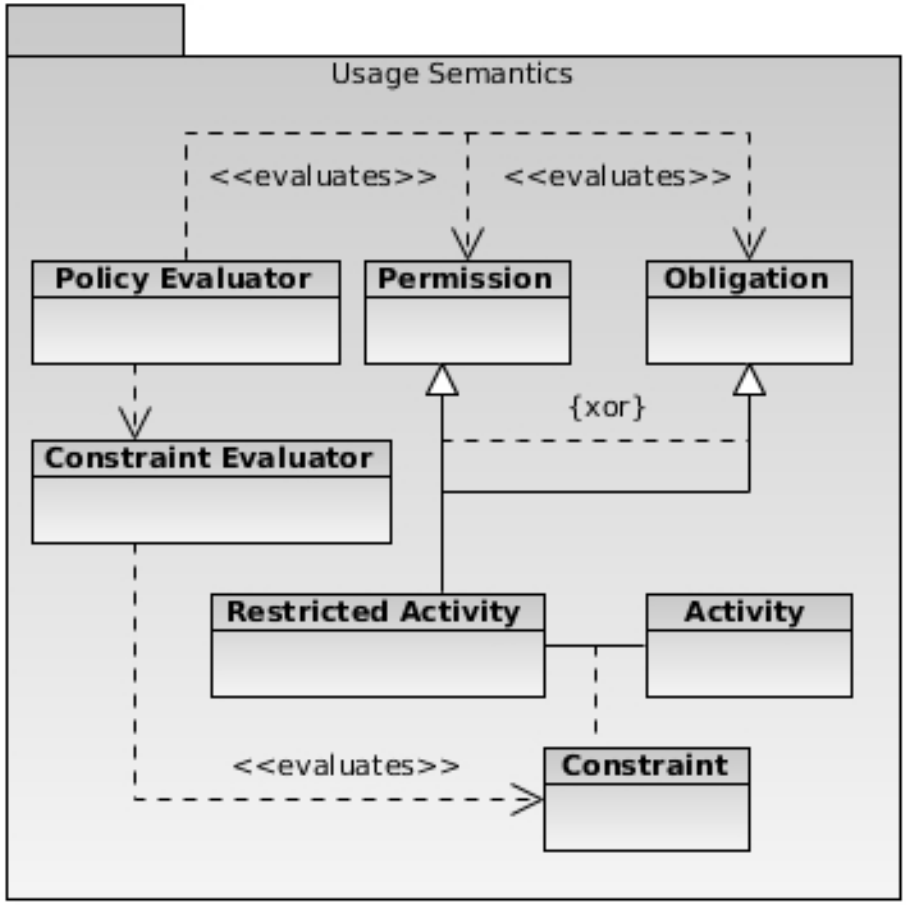
The *Runtime* accesses and activates a *policy* and manages a *context* to which the policy is given a reference.

The *context* has access to information about the *environment*, *resource* managed, and the *subject* using the *resource*.

Interactions are described by specific *usage semantics* embodied in the *policy*.

Design — Usage Semantics

Usage Semantics:



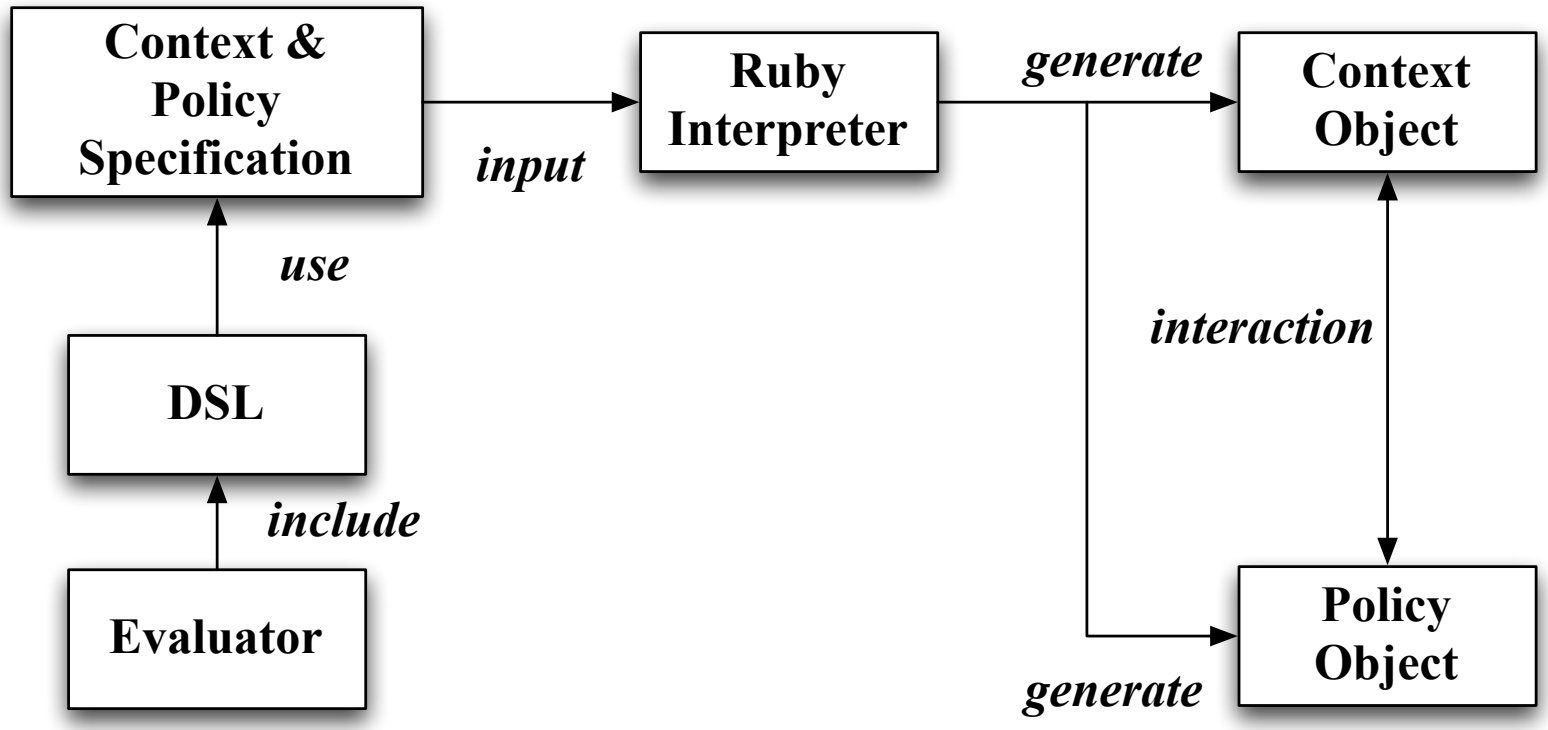
A *policy evaluator* examines and rectifies both *permissions* and *Obligations*.

A *restricted activity* is a specialization of either a *permission* or *obligation*, and is associated with a specific *activity*.

The association between an *activity* and a *restricted activity* is embodied by a *constraint*, which is evaluated by a *constraint evaluator*.

Implementation — Lifecycle

Typical DSL Lifecycle:



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Implementation — Attributes

Context			
Entity	**Property (p)**	**Domain (D_p)**	**Functions (F_p)**
Environment (E)	OperatingSystem	{Windows, OSX, SELinux}	equatable
	Device	{Workstation, Handheld, Blackberry, Terminal}	equatable
	SecurityDomain	{ ABNet, SECNet, TELNet, OMNINet}	comparable
Subject (S)	SecurityClearance	{Top Secret, Secret, Confidential}	comparable
	Project	{Zebra, Yuma, Lion}	equatable
	Role	{Alpha, Beta, Delta}	equatable
Resource(R)	SecurityClassification	{ Top Secret, Secret, Confidential, Unclassified}	comparable

Environment (E):

Operating System $\rightarrow$ {Windows, OSX, SELinux} $\rightarrow$ equatable

Device $\rightarrow$ {Workstation, Handheld, Blackberry, Terminal} $\rightarrow$ equatable

Security Domain $\rightarrow$ {ABNet, SECNet, TELNet, OMNINet} $\rightarrow$ comparable

Subject(S):

SecurityClearance $\rightarrow$ {Top Secret, Secret, Confidential} $\rightarrow$ comparable

Project $\rightarrow$ {Zebra, Yuma, Lion} $\rightarrow$ equatable

Role $\rightarrow$ {Alpha, Beta, Delta} $\rightarrow$ equatable

Resource(S):

Classification $\rightarrow$ {TopSecret, Secret, Confidential, Unclassified} $\rightarrow$ comparable

Implementation — Properties

```
property :OperatingSystem do
  values :windows, :osx, :selinux
  functions :set, :get, :equatable
end

property :device do
  values :workstation, :handheld, :blackberry, :terminal
  functions :set, :get, :equatable
end

property :project do
  values :zebra, :yuma, :lion
  functions :set, :get, :equatable
end

property :role do
  values :alpha, :beta, :delta
  functions :set, :get, :equatable
end
```

Implementation — Properties

```
property :securitydomain do
  values :abnet, :secnet, :telnet, :omninet
  functions :set, :get, :comparable
  order :abnet, :secnet, :telnet, :omninet
end

property :securityclearance do
  values :topsecret, :secret, :confidential
  functions :set, :get, :comparable
  order :topsecret, :secret, :confidential
end

property :securityclassification do
  values :topsecret, :secret, :confidential,
    :unclassified
  functions :set, :get, :comparable
  order :topsecret, :secret, :confidential,
    :unclassified
end
```

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Implementation — Entity, Context

```
entity :subject do
  contains :project, :role, :securityclearance
end

entity :environment do
  contains :device, :operatingsystem, :securitydomain
end

entity :resource do
  contains :securityclassification
end
```

```
context :multilevelsecurity do
  contains :subject, :resource, :environment
end
```

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Implementation — Activities, Constraints

```
view = activity :view do
  # Some activity to enable viewing
end

c1 = constraint do
  securityclassification >= :secret
    && project == :yuma
    && securityclearance >= :secret
    && device == :blackberry
    && securitydomain >= :secnet
end

restricted_view = restrict view do
  with c1
end
```

```
authorization = activity :project_authorization do
  is_authorized? :yuma
end
```

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Implementation — Policies

```
pol = policy do
  policy_evaluators :standard
  constraint_evauators :propositional
  permit restricted_view do
    when authorization
  end
end
```

```
pol = policy do
  policy_evaluators :standard
  constraint_evauators :propositional
  permit restricted_view do
    when authorization
    count_limit restricted_view, 5
  end
end
```

Implementation - Interface

- **permissions?()**. Returns the set of permissions for a given policy.
- **obligations?(a)**. Returns the set of all obligations associated with a given permission.
- **remaining_obligations(a)**. Returns the set of remaining obligations for a given permission.
- **remaining_count(a)**. Returns the set of remaining count for a given permission.
- **allowed?(a, ctx)**. A boolean function that returns *true/false* whether a given activity can be carried out under a given context.
- **reset()**. Resets the policy by resetting its state.

Application - CC REL

- The Creative Commons Rights Expression Language
- RDFa (Resource Description Framework in attributes) for HTML Web pages and resources referenced therein
- XMP (Extensible Metadata Platform) for stand-alone media
- `http://wiki.creativecommons.org/CC_REL`

Application - RDFa in HTML

- Can simply associate web content with a CC license:

```
<div about="" instanceof="cc:Work" xmlns:cc="http://creativecommons.org/ns#"
     xmlns:dc="http://purl.org/dc/elements/1.1/" align="center">

    <a rel="license" href="http://creativecommons.org/licenses/by/3.0/">
    <img alt="Creative Commons License"
         src="http://i.creativecommons.org/l/by/3.0/us/88x31.png" /></a><br />

    <span property="dc:title">The Lessig Blog</span>,
    a <span rel="dc:type" href="http://purl.org/dc/dcmitype/Text">
    collection of texts</span>

    by <a property="cc:attributionName" rel="cc:attributionURL"
        href="http://lessig.org/"> Lawrence Lessig </a>,<br />

    is licensed under a
    <a rel="license" href="http://creativecommons.org/licenses/by/3.0/">
    Creative Commons Attribution License</a>.<br />

    There are
    <a rel="cc:morePermissions" href="http://lessig.org/blog/other-license">
    alternative licensing options</a>
</div>
```

- But what are the semantics of `http://creativecommons.org/licenses/by/3.0/`?

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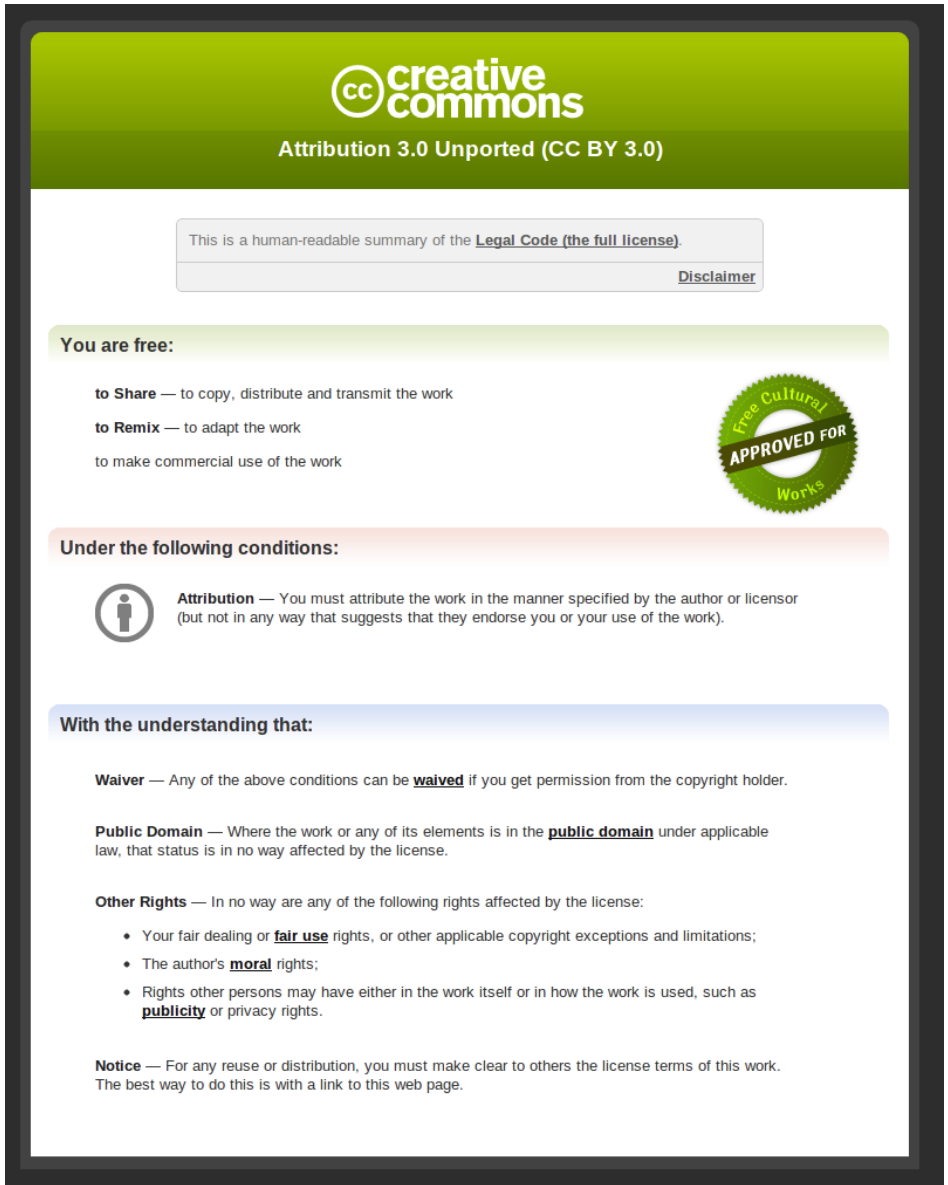
Application - License Deed Webpage

- Can a machine derive this page's semantics?



creative commons

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This is a human-readable summary of the **Legal Code (the full license)**.

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- The author's **moral** rights;
- Rights other persons may have either in the work itself or in how the work is used, such as **publicity** or privacy rights.

Notice — For any reuse or distribution, you must make clear to others the license terms of this work. The best way to do this is with a link to this web page.

Application - RDF Embedded

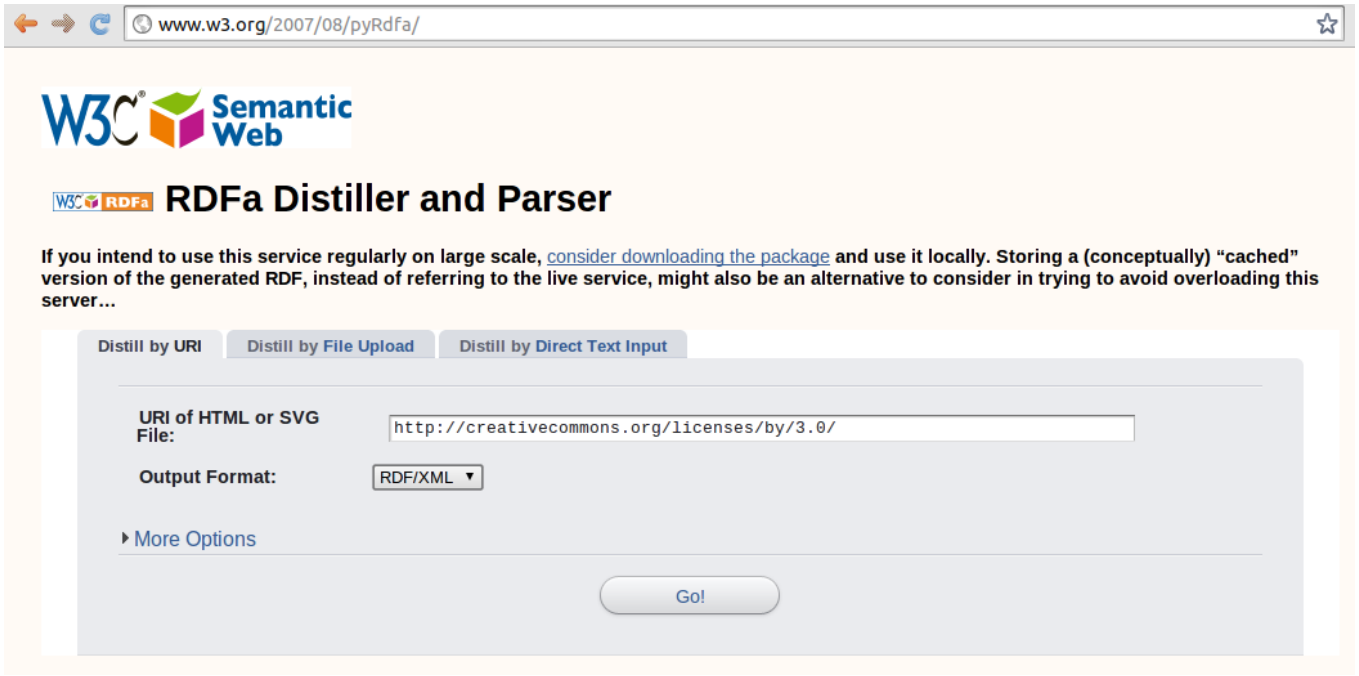
- The previous webpage contains the following embedded RDF:

```
<!-- RDF code here for backwards compatibility.  Please use the
     license's RDFa instead. -->
<!-- <rdf:RDF xmlns="http://creativecommons.org/ns#" xmlns:rdf="http://www.w3.org/1999/02/22-rdf
      -syntax-ns#">
<License rdf:about="http://creativecommons.org/licenses/by/3.0/">
    <permits rdf:resource="http://creativecommons.org/ns#DerivativeWorks"/>
    <permits rdf:resource="http://creativecommons.org/ns#Distribution"/>
    <permits rdf:resource="http://creativecommons.org/ns#Reproduction"/>
    <requires rdf:resource="http://creativecommons.org/ns#Attribution"/>
    <requires rdf:resource="http://creativecommons.org/ns#Notice"/>
</License>
</rdf:RDF> -->
```

- From this, a machine can determine that this license:
  - Permits:
    - `#DerivativeWorks`, `#Distribution`, `#Reproduction`
  - Requires:
    - `#Attribution`, `#Notice`
- However, what do these things mean? How are they implemented?

Application - RDFa Embedded

- In addition to the RDF shown on previous slide, CC License Deeds also have embedded RDFa
- You can see that a machine can parse this data with something like the RDFa Distiller and Parser Tool:



Application - RDFa Distiller

```
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF
  xmlns:cc="http://creativecommons.org/ns#"
  xmlns:dc="http://purl.org/dc/elements/1.1/"
  xmlns:dct="http://purl.org/dc/terms/"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:xml="http://www.w3.org/XML/1998/namespace"
>
  <rdf:Description rdf:about="http://creativecommons.org/">
    <dct:title xml:lang="en">Creative Commons</dct:title>
    <dc:title xml:lang="en">Creative Commons</dc:title>
  </rdf:Description>

  <cc:License rdf:about="http://creativecommons.org/licenses/by/3.0/">
    ...
    <dct:creator rdf:resource="http://creativecommons.org/"/>
    <dc:creator rdf:resource="http://creativecommons.org/"/>
    <cc:requires rdf:resource="http://creativecommons.org/ns#Attribution"/>
    <cc:requires rdf:resource="http://creativecommons.org/ns#Notice"/>
    <cc:permits rdf:resource="http://creativecommons.org/ns#DerivativeWorks"/>
    <cc:permits rdf:resource="http://creativecommons.org/ns#Reproduction"/>
    <cc:permits rdf:resource="http://creativecommons.org/ns#Distribution"/>
    <dct:identifier xml:lang="en">CC BY 3.0</dct:identifier>
    <dct:title xml:lang="en">Attribution 3.0 Unported</dct:title>
    <dc:identifier xml:lang="en">CC BY 3.0</dc:identifier>
  </cc:License>
</rdf:RDF>
```

Application - CC RDF Schema

- License RDF(a) references `#DerivativeWorks`, etc., in the CC namespace that's defined by a schema that's human-readable and machine-readable RDF.
- But... how immediately machine actionable is this schema?
- Partial screenshot below:

- We would like to investigate replacing or augmenting RDF(a) in the license deed with a license that's described with our DSL

Application - DSL

- By investigating replacing the contents of a license like `http://creativecommons.org/licenses/by/3.0/` with something that expresses the license in terms our DSL, we hope to:
  - Maintain equivalent license semantics
  - Express the semantics in a form that is easier for humans to read and write
  - Enable a machine to more directly execute the license and reason over it

Conclusions

- Internal DSLs are convenient, but probably not appropriate for real systems
- Overall we like the DSL but could do without some of the Ruby cruft (e.g. **do...end**, etc.)
- Application and Optimization