Semantics-Enabled Web Policies for Privacy Protection and Digital Rights Management: Current Status and Future Trends

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Part I

Research Goals

Long Term Research Goals

SemPIF Framework: PIF + Meta-PIF

- SemPIF: : Semantic PIF and Semantics-enabled meta-PIF
- Policy Interchange Format (PIF)
- Meta-PIF
- SemPIF for privacy protection
- SemPIF for DRM
- SemPIF for multiple domains
- SemPIF for policies legalized

Short Term Research Goals

Privacy Protection

Semantics-Enabled privacy protection policies

- Formal semantic model of P3P and EPAL
- Semantic enforcement of privacy protection policies
- Semantics-enabled privacy protection system on the Web

Current Status[15]

- *DL* + *log*-based ontology+rule on P3P
- Ontology-based privacy protection policies
- Rule-based privacy protection policies
- Semantics-enabled of privacy protection policies
- Policies alignment between semantics-enabled P3P and EPAL

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Short Term Research Goals
Digital Rights Management (DRM)

Semantics-Enabled DRM policies

- Formal semantic model of ODRL/XrML
- Semantics-enable of DRM policies
- Semantic enforcement of DRM system on the Web

Current Status[14]

- SWRL-based ontology+rule on ODRL
- Ontology-based usage and delegation rights of DRM
- Rule-based usage and delegation rights of DRM
- DRM policies for fair use of Intellectual Property (IP)

Short Term Research Goals
Digital Rights Management (DRM)

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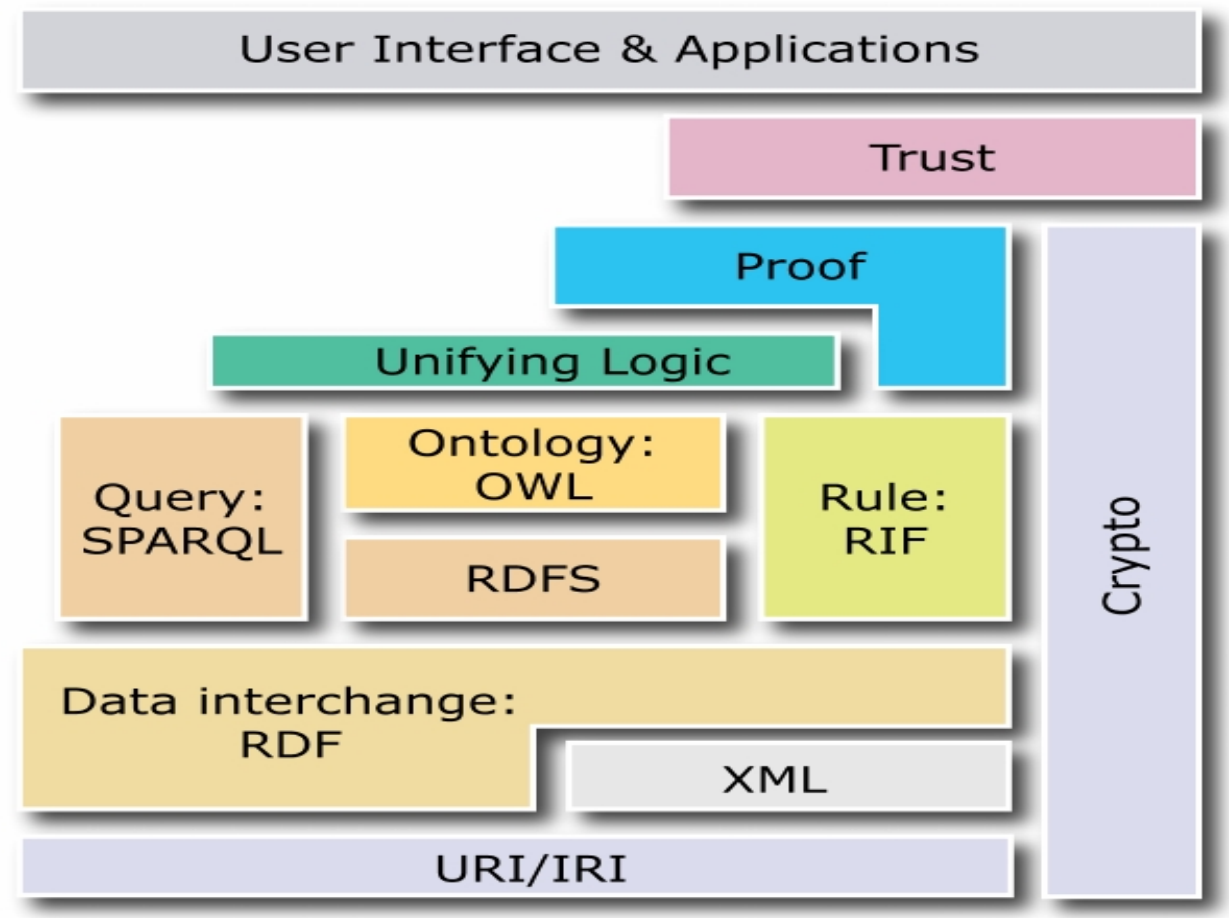
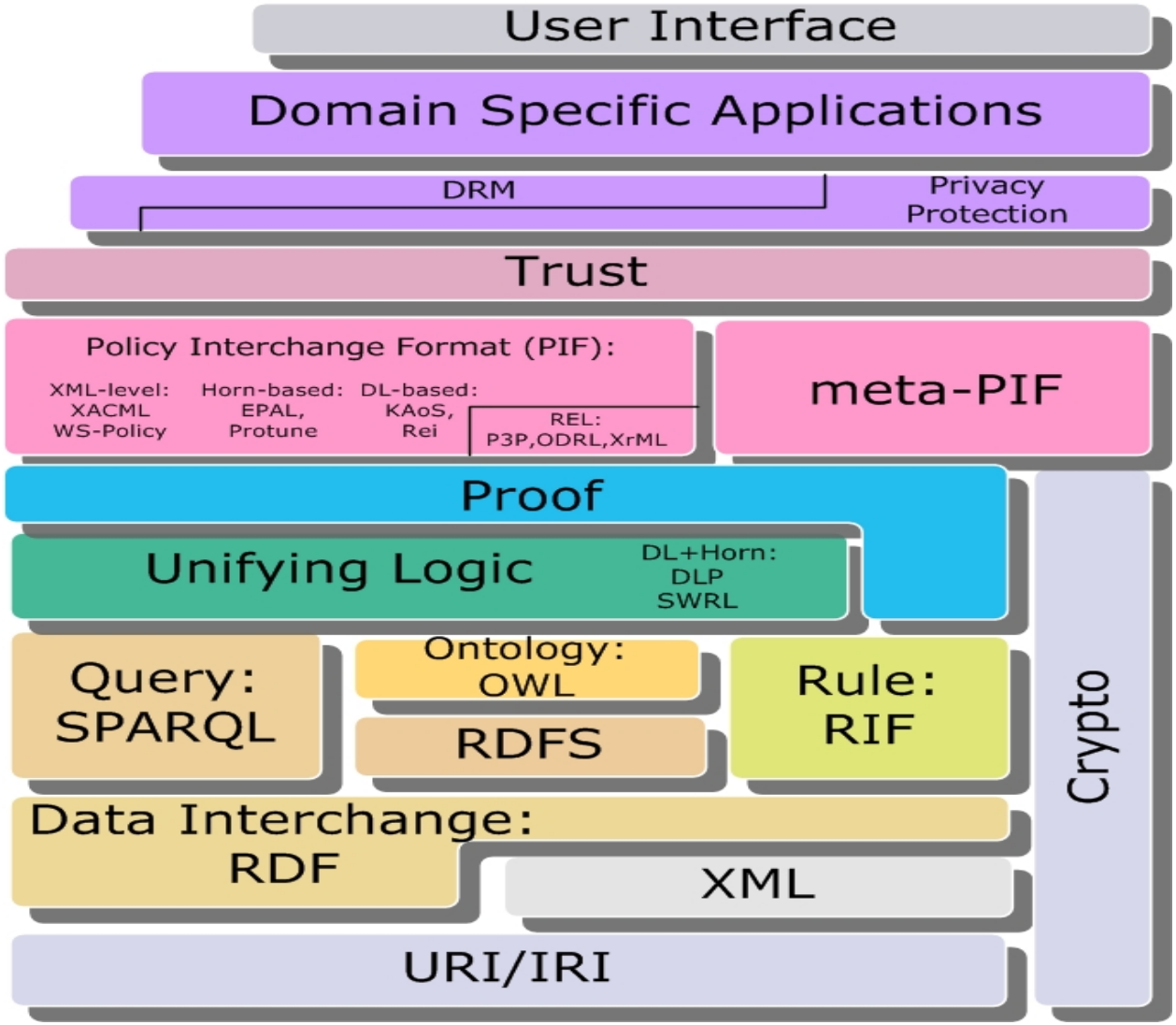
Part II

SemPIF: PIF + Meta-PIF

Well-Known Semantic Web Layer Cake(2007 Version)



SemPIF Extends Semantic Web



SemPIF's Related Work

Where Are Current Available Policy Frameworks?

- W3C PLING
- OMG SBVR
- MIT DIG Rein
- FP6 REWERSE Protune
- FP6 IST-ESTRELLA LKIF

What Is the Features of SemPIF

- Extends from the Semantic Web architecture
- Explicitly decoupling meta-PIF from PIF
- Applying a combination of ontology+rule for PIF and meta-PIF
- SemPIF for various protection domains, e.g. privacy protection and DRM

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Part III

Semantics-Enabled Web Policies

What Do You Mean Policies?

- Declared as knowledge bases, i.e., ontologies or/and rules
- Reducing program coding to a minimum level
- Enabling automated documentation
- Framework supports policy interoperability
- Low deployment and maintenance cost
- Context of policy is machine understandable
- Maybe supports automatic negotiation between agents

Policy Specification, Enforcement, and Integration, WG I2, REWERSE FP6

What Do You Mean Meta-Policy?

- A policy about policies
- Providing a set of rules to enforce the adding and changing management services of multi-policies
- Setting up priority of polices to coordinate, enforce, and even negotiate multi-policies on the Web

Hosmer, H. H., Metapolicies I, ACM SIGSAC Review, 1992"

XML-based Policy Lacks Semantics

XML-based policies

- XrML [17] $\Leftarrow$ digital rights expression language
- ODRL [16] $\Leftarrow$ digital rights expression language
- P3P [5] $\Leftarrow$ privacy rights expression language
- EP3P(EPAL) [1] $\Leftarrow$ privacy rights expression language
- XACML [1] $\Leftarrow$ general policy language

Pure FOL-based Policy Is Not Web-Enabled

Formal semantics of DL ($\subset$ FOL) or LP for policies

- Semantic ODRL [26] $\Leftarrow$ FOL semantics
- Semantic XrML [10] $\Leftarrow$ FOL semantics
- Semantic P3P [33] $\Leftarrow$ relational semantics
- FAF [18] $\Leftarrow$ LP semantics
- Semantic E-P3P (or EPAL) [1] $\Leftarrow$ FAF semantics
- Rein, KAoS [31] $\Leftarrow$ DL-based FOL semantics
- Protune [3] $\Leftarrow$ LP semantics

Semantics-Enabled Web Policies

Web policies from semantic web languages

- Ontology Languages: RDF(S), OWL-DL, OWL2
- Rules Languages: N3, RuleML, RIF
- Ontology+Rule Language: SWRL, OWL2+RIF

Web policies from ontology+rule

- Policy vs. Regulation (or Law)
- Policy Language vs. Policies
- Semantics-enabled Policy Language
- Semantics-enabled Meta-PIF

Semantics-Enabled Web Policies

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Semantics-Enabled Web Policies (conti.)

Why use ontology+rule?

- Exploiting semantic web research
- Two major knowledge representations
- Automatic machine processing of policies
- Choosing which ontology+rule is not easy!

Why not use ontologies or rules alone?

- Policies might be DL-based semantics and LP-based semantics
- Power enhancement of policies from ontologies and rules
- Different knowledge integration, interchange, and interoperation
- Options to use ontologies, rules or both

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Semantics-Enabled Web Policies (conti.)

Which ontology+rule combination for Web Policies?

- We do not know yet!
- Decidability of computation
- Expressive power of ontology+rule
- Semantics differences between DL and LP
- Uni-(or bi-)directional of knowledge flow
- Homogeneous of ontology+rule
- Heterogeneous (or Hybrid)) of ontology+rule

Semantics-Enabled Web policies

Homogeneous ontology+rule [29]

- CARIN [20] (limited expressive power)
- Description Logic Program (DLP) [8] (too restricted)
- Semantic Web Rule Language(SWRL) [12] (undecidable unless DL-safe rules)

Future Semantics-Enabled Web Policies (conti.)

Hybrid ontology+rule [29]

Positive Datalog rules

- (Disjunctive)AL-log [6] $\Leftarrow$ decidability of *ALC* plus positive, recursive DL-safe rules
- DL-safe rules [23] $\Leftarrow$ decidability of *SHOIN* plus positive, recursive DL-safe rules

Non-monotonic Datalog rules

- DL-log safe hybrid Knowledge Bases [27] $\Leftarrow$ decidability of DLs/FOL plus non-monotonic, recursive DL-safe rules
- DL+log [28] $\Leftarrow$ decidability of arbitrary DLs plus non-monotonic, recursive weakly DL-safe rules
- Hybrid MKNF Knowledge Bases [22] $\Leftarrow$ mixing OWA and CWA reasoning in DL-safe rules

Future Semantics-Enabled Web Policies (conti.)

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Part IV

Privacy Protection

Privacy Protection on the Web

Privacy Protection on Web 1.0

- Privacy protection policies representation through natural language
- Static personal profile and digital traces
- Information disclosure policies and mechanisms are embedded together
- Does the website comply the policies announcement is unknown!

Privacy Protection on Web 2.0

- APPEL/P3P provides information disclosure's opt-in/opt-out and negotiation mechanisms
- More challenging to protect a variety of dynamic digital traces
- Does the website comply the policies announcement is still unknown!

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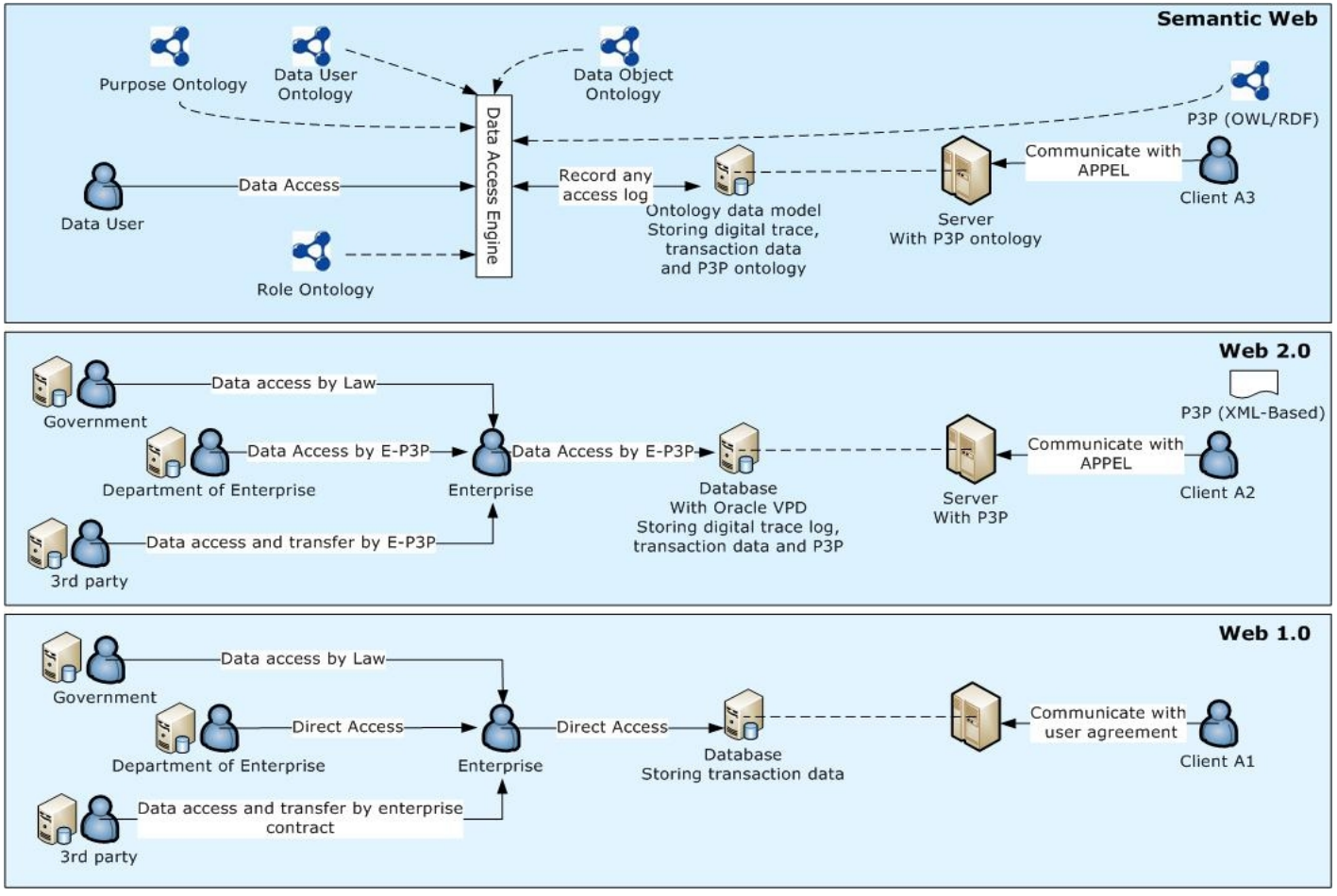
Privacy Protection on the Web

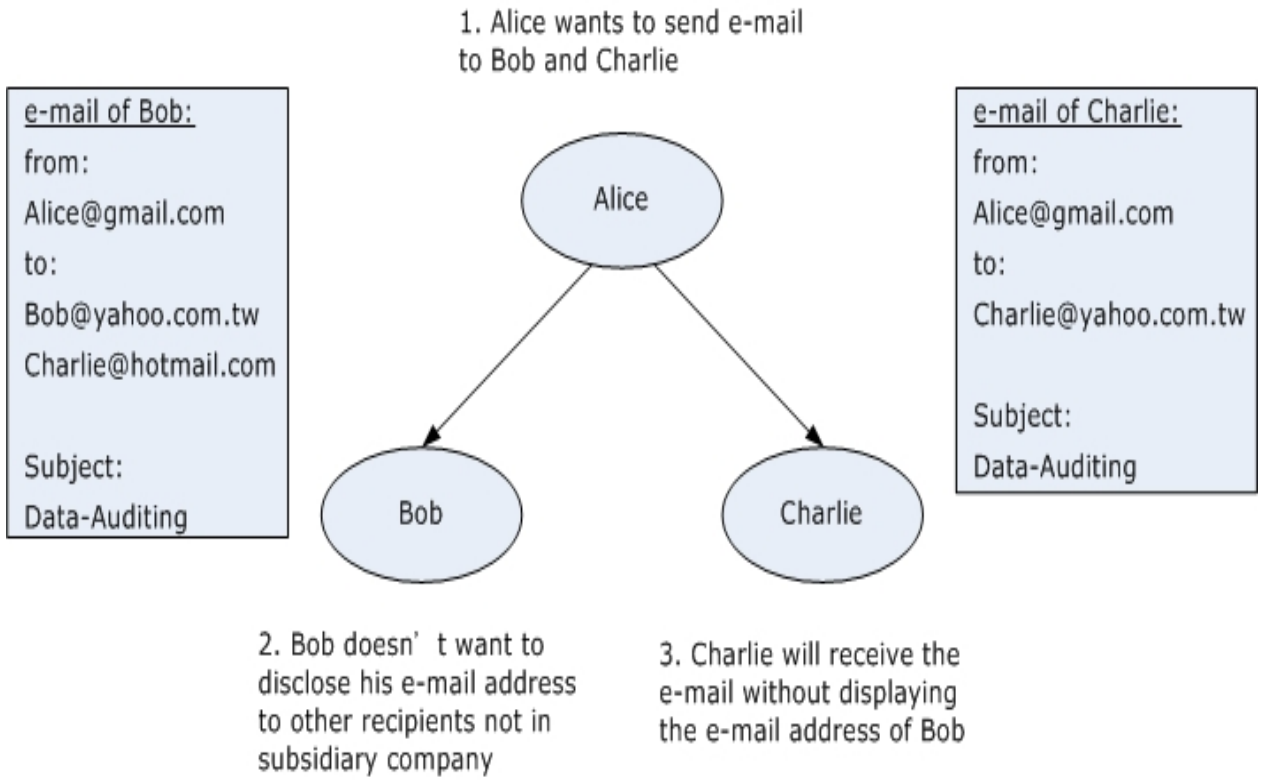
Privacy Protection on Web 3.0

- We have a separation of privacy protection protection policies and mechanisms.
- Personal profile and digital traces are semantics-enabled data model.
- Automatic enforcement of the semantics-enabled privacy protection policies
- Auditing and verifying the compliance of privacy policies to the laws
- Do we need Sound and complete semantics-enabled policies from the legal privacy laws?

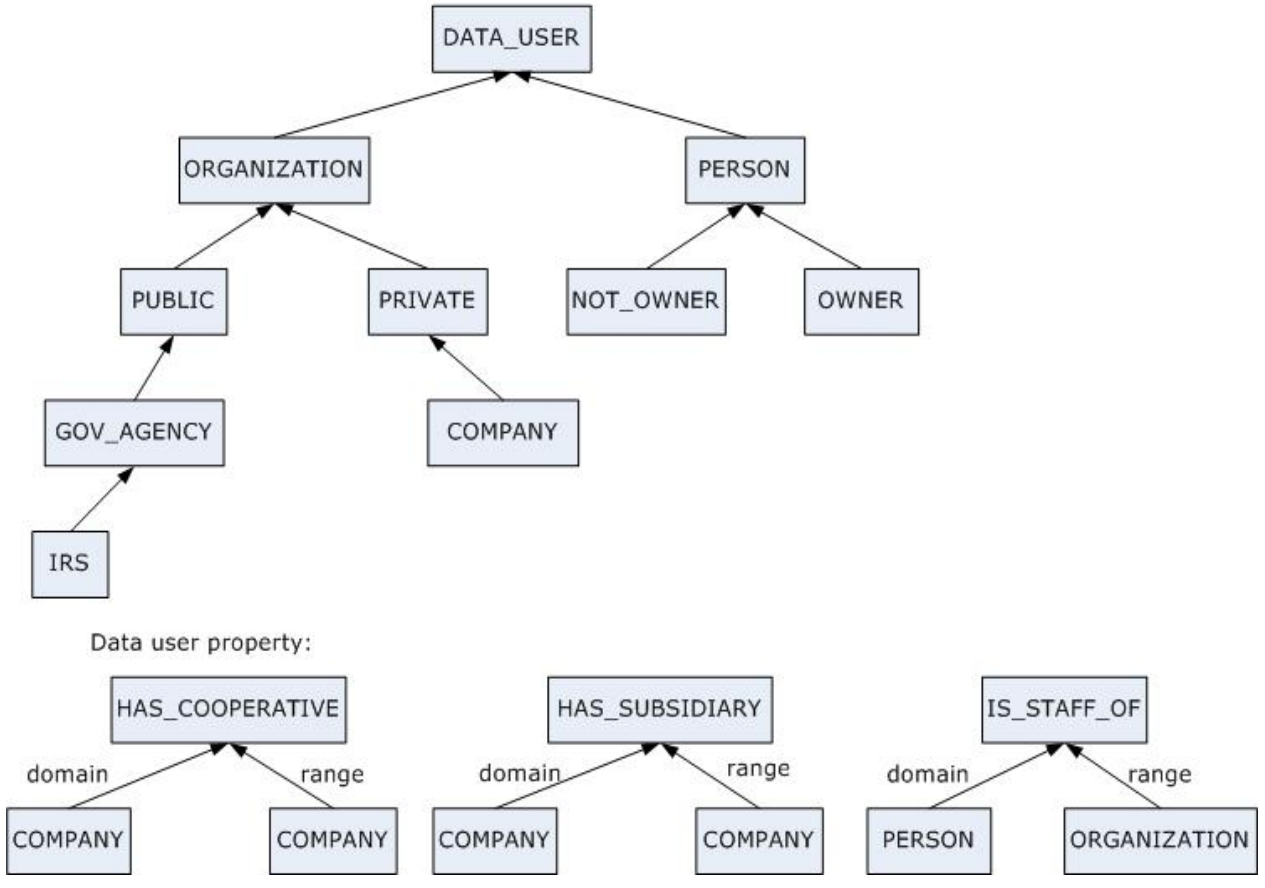
Privacy Protection on Different Web Generations



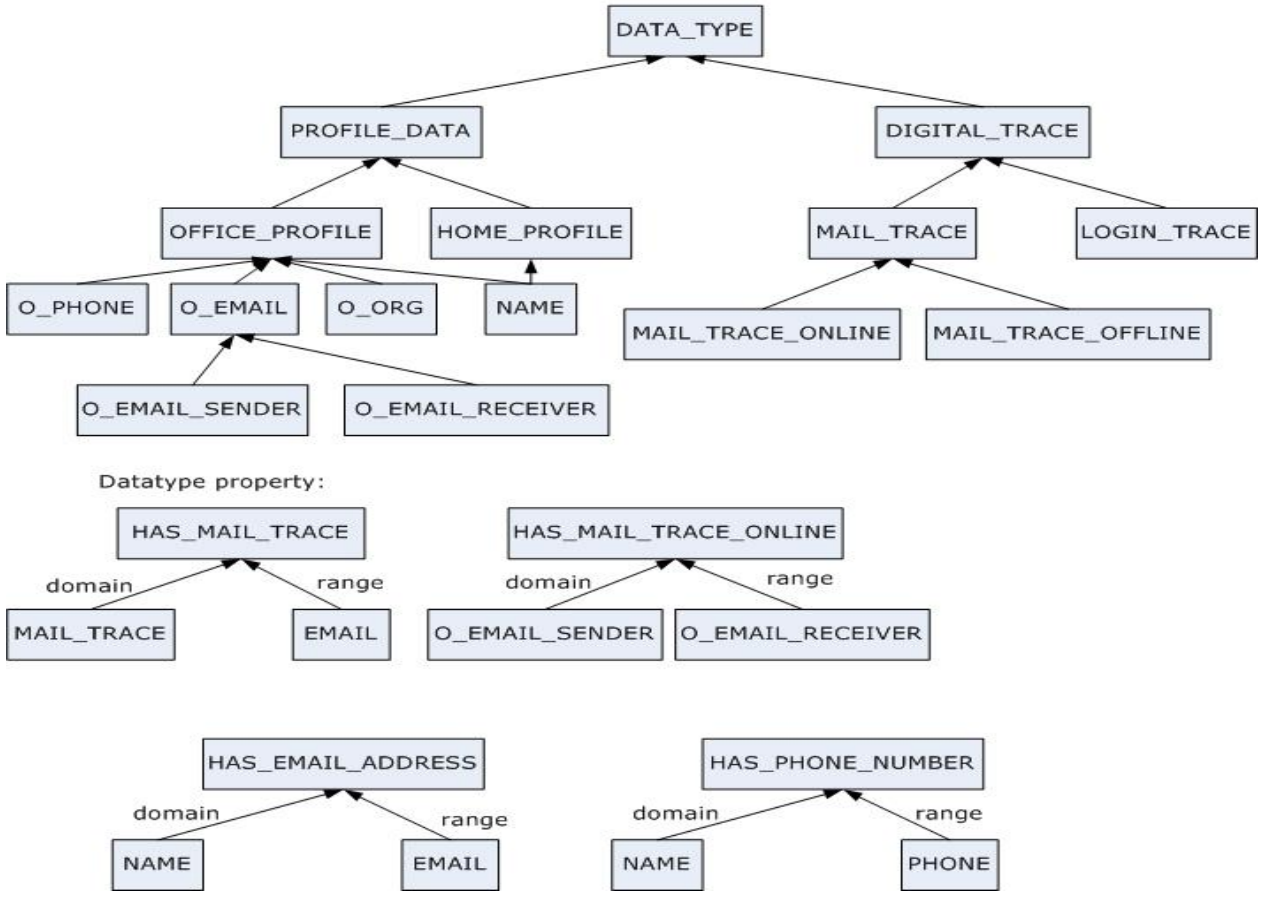
Non-disclosure of recipient's email address



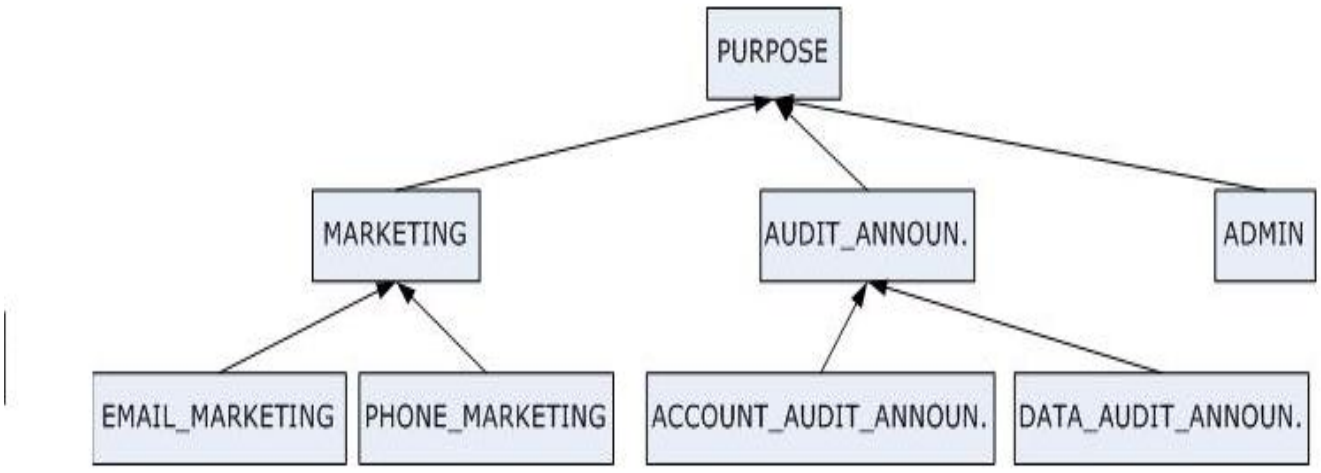
Data User Ontologies (conti.)



Data Type Ontologies (conti.)



Purpose Ontology (conti.)



Ontology Module

Example (Ontology Module's Axiom)

- $COMPANY \sqsubseteq PRIVATE$
- $PRIVATE \sqsubseteq ORGANIZATION$
- $OWNER \sqsubseteq PERSON$
- $COMPANY \overset{domain}{\longleftarrow} HAS\_COOPERATIVE \overset{range}{\longrightarrow} COMPANY$
- $COMPANY \overset{domain}{\longleftarrow} HAS\_SUBSIDIARY \overset{range}{\longrightarrow} COMPANY$
- $HAS\_COOPERATIVE \equiv HAS\_COOPERATIVE^{-}$
- $PERSON \overset{domain}{\longleftarrow} IS\_STAFF\_OF \overset{range}{\longrightarrow} ORGANIZATION$
- $MAIL\_TRACE \overset{domain}{\longleftarrow} HAS\_MAIL\_TRACE \overset{range}{\longrightarrow} EMAIL$
- $EMAIL \sqsubseteq \exists\ HAS\_MAIL\_TRACE\_ONLINE^{-}.O\_EMAIL\_SENDER$
- $EMAIL \sqsubseteq \forall\ HAS\_MAIL\_TRACE\_ONLINE.O\_EMAIL\_RECEIVER$
- $DATA\_AUDIT\_ANNOUN. \sqsubseteq AUDIT\_ANNOUN.$

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Ontology Module

Example (Ontology Module's Facts)

- *ORGANIZATION(G)*
- *HAS_SUBSIDIARY(G, J-Corp.)*
- *HAS_COOPERATIVE(G, Q-Corp.)*
- *IS_STAFF_OF(Alice, J-Corp.)*
- *IS_STAFF_OF(Bob, J-Corp.)*
- *IS_STAFF_OF(Charlie, Q-Corp.)*
- *HAS_EMAIL_ADDRESS (Charlie,Charlie@hotmail.com)*
- *O_EMAIL_RECEIVER(Bob@yahoo.com.tw)*
- *HAS_EMAIL_ADDRESS (Alice,Alice@gmail.com)*
- *HAS_EMAIL_ADDRESS (Bob,Bob@yahoo.com.tw)*
- *O_EMAIL_SENDER(Alice@gmail.com),*
- *O_EMAIL_RECEIVER (Charlie@hotmail.com)*
- *HAS_MAIL_TRACE_ONLINE (Alice@gmail.com,Bob@yahoo.com.tw)*
- *HAS_MAIL_TRACE_ONLINE (Alice@gmail.com,Charlie@hotmail.com)*

Rule Module

Example (Rule Module's Rules)

- *cando(?c,?b-email, display)*
  ⟸ opt-in(?b,?b-email,?p)), data-user(?c), data-owner(?b),
  HAS_EMAIL_ADDRESS(?b,?b-email). ← (a1)
- *cando(?c,?b-email, nill)*
  ⟸ opt-out(?b,?b-email,?p)), data-user(?c), data-owner(?b),
  HAS_EMAIL_ADDRESS(?b, ?b-email). ← (a2)
- *opt-in(?b,?b-email,?p)*
  ⟸ data-owner(?b), data-user(?c), purpose(?p), data-type(?b-email),
  IS_STAFF_OF(?b,?c1), IS_STAFF_OF(?c, ?c2), HAS_SUBSIDIARY(?c1,?c2),
  HAS_MAIL_TRACE_ONLINE(?a-email,?c-email),
  O_EMAIL_SENDER(?a-email), O_EMAIL_RECEIVER(?c-email). ← (a3)
- *opt-out(?b,?b-email,?p)*
  ⟸ data-owner(?b), data-user(?c), purpose(?p), data-type(?b-email),
  IS_STAFF_OF(?b,?c1), IS_STAFF_OF(?c, ?c2), HAS_COOPERATIVE(?c1,?c2),
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- *opt-out(?b,?b-email,?p)*
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  O_EMAIL_SENDER(?a-email), O_EMAIL_RECEIVER(?c-email). ← (a4)

Rule Module

Example (Rule Module's Facts)

- *data-user(Bob), data-owner(Bob),*
- *data-user(Charlie), data-owner(Charlie),*
- *purpose(data-auditing),*
- *data-type(Bob@yahoo.com.tw),*
- *data-type(Charlie@hotmail.com),*
- *opt-in(c,Charlie@yahoo.com, data-auditing),*
- *cando(Bob,Charlie@yahoo.com,display),*
- *cando(Charlie,Bob@yahoo.com.tw,nill),*
- *opt-out(b,Bob@yahoo.com.tw, data-auditing)*

Part V

Digital Rights Management

Agreement for Usage (Transfer) Rights

Definition (license agreement)

A principal $Prin_o$ allows another principal $Prin_{u_i}$ to use an asset r presumably owned by $Prin_o$, where $Prin_o$ is an asset owner, $Prin_{u_i}$ is one of n asset users, where $i \in (1, \cdots, n)$.

Prerequisites Expressions

Definition (prerequisites of agreement)

A prerequisite is either a constraint, a requirement, or a condition of rights agreement. If all of the prerequisites are met, then policies say that the agreement's users may perform the action for the license agreement's assets.

Definition (prerequisites as ontology expressions)

- $MaxCardinality{:}\leq_{\exists u}\ hasUsageCount_{\exists p}.Asset$
- $MaxCardinality{:}\ \leq_{\exists t}\ hasTransferCount_{\exists p}.Asset$
- $Cardinality{:}\ =_{\exists a}\ hasPrepaid_{\exists p}.Party$
- $Validity\ of\ time\ interval\ \forall Time \in (t_1, t_2){:}$
  $\geq_{\exists t_1}\ hasDateTime_{\exists p}.Time \wedge \exists \leq_{t_2}\ hasDateTime_{\exists p}.Time$

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- *Validity of time interval* $\forall Time \in (t_1, t_2)$*:*

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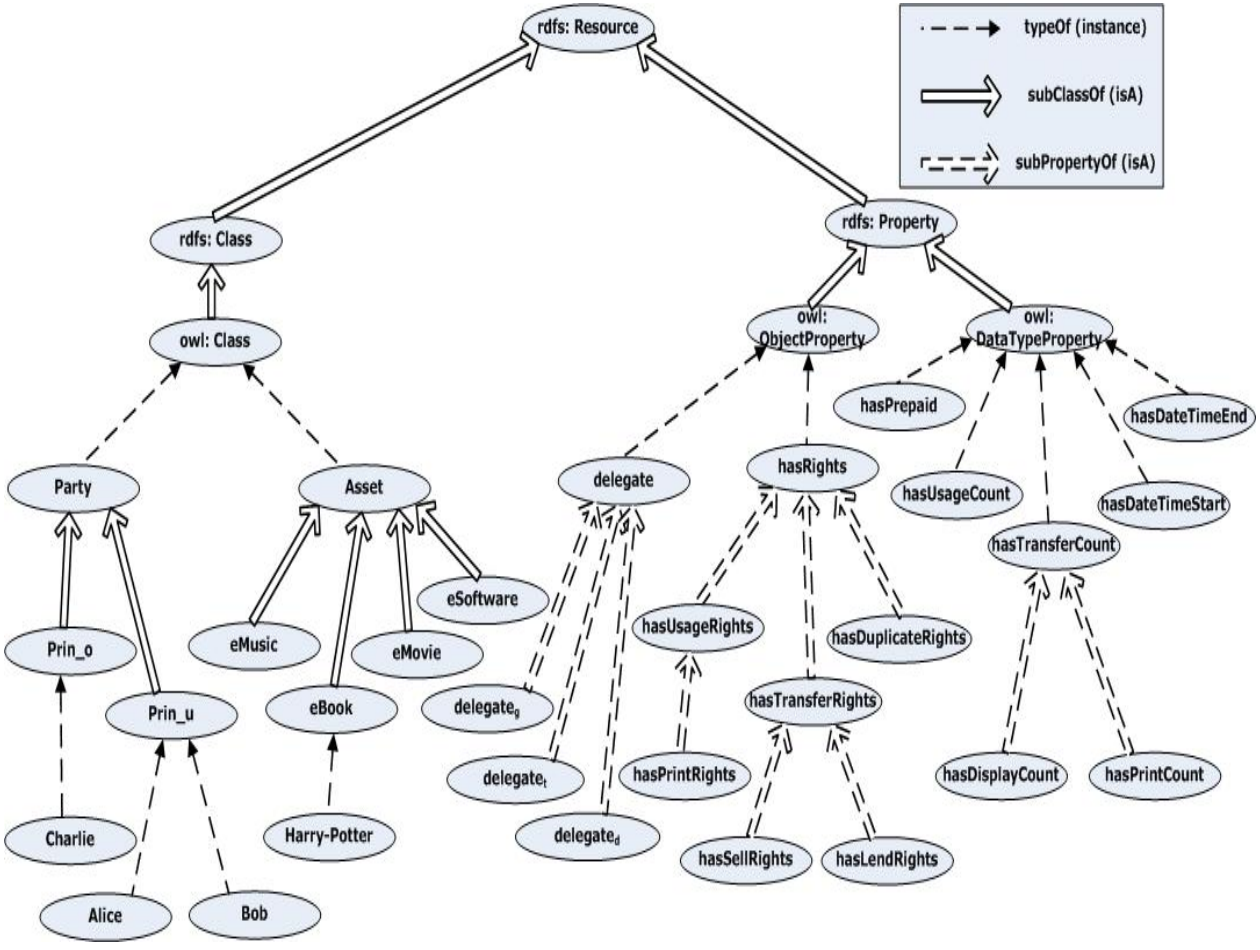
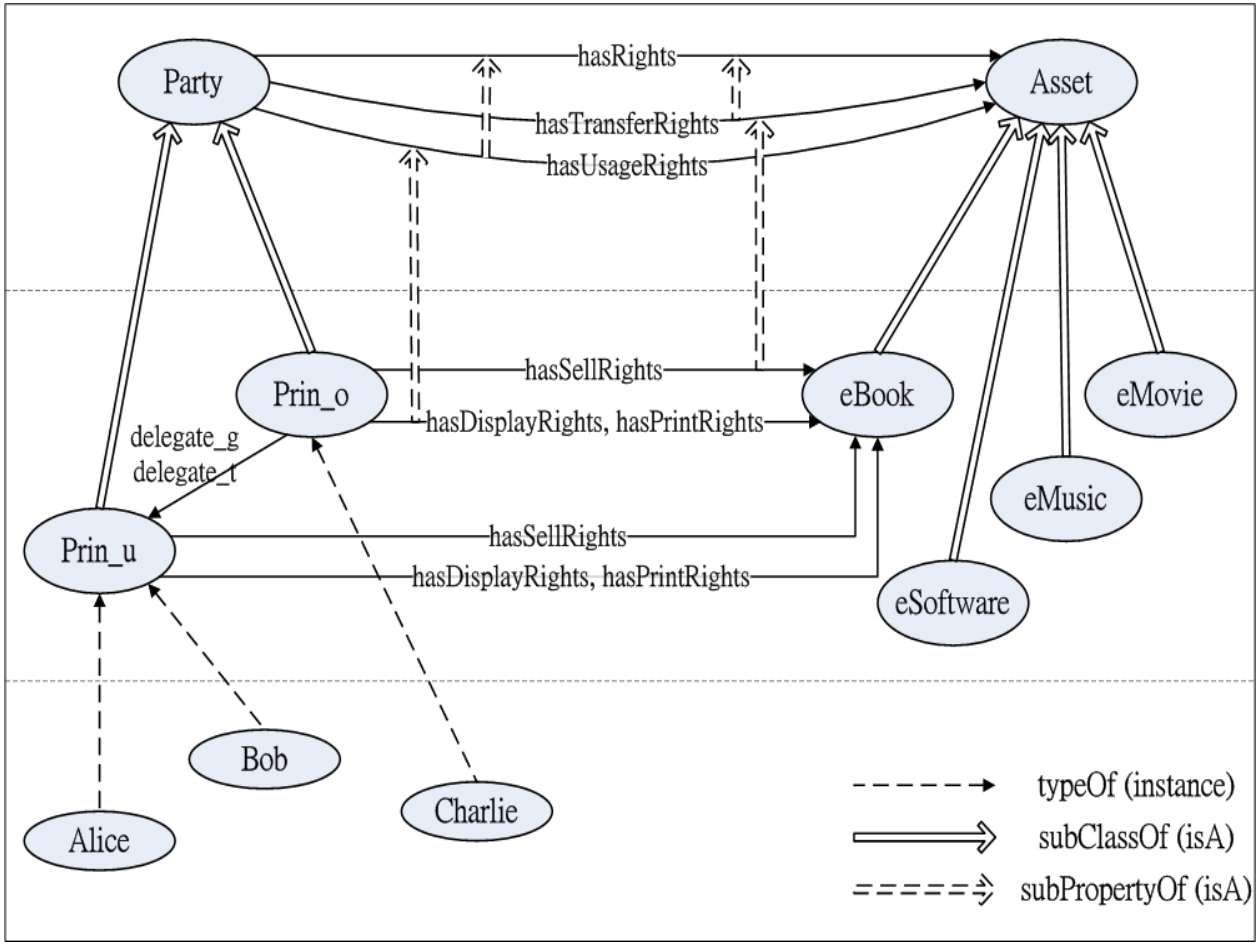
A Rights Delegation Ontology



A Rights Delegation Snapshot



Rights Delegation Policies

Definition (usage (or transfer) rights delegation)

The class and property terms in this rights delegation ontology will be considered as antecedents or conclusion(s) in the usage and transfer rights delegation rules to enforce real rights delegation inference.

Transfer Rights Delegation

Definition (*hasTransferRights*)

- *hasTransferRights* is an abstract property describing the transfer rights delegation of usage rights.
- The domain class of *hasTransferRights* is *Party* and the range class is *Asset*.

Definition ($delegate_g$ and $delegate_t$)

- $Prin_o$ might use $delegate_g$ to transfer usage rights only to $Prin_{u_i}$, but does not delegate his transfer rights.
- $Prin_o$ might use $delegate_t$ for both usage and transfer rights to propagate further.

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Rules for Rights Transfer Delegation

Definition (rules for usage rights delegation)

- $hasUsageRights(?x, ?r) \wedge hasTransferRights(?x, ?r) \Longrightarrow hasUsageTransferRights(?x, ?r) \Leftarrow (o1)$
- $hasUsageTransferRights(?x, ?r) \wedge delegate_g(?x, ?y) \wedge hasPrepaid(?y, ?a) \wedge <_{\exists u} hasUsageCount(?r) \Longrightarrow hasUsageRights(?y, ?r) \Leftarrow (o2)$

Definition (rules for transfer rights delegation)

- $hasUsageRights(?x, ?r) \wedge <_{\exists u} hasUsageCount(?r) \wedge \geq_{\exists t_1} hasDateTime(?t) \wedge \leq_{\exists t_2} hasDateTime(?t) \Longrightarrow Permitted(Usage, ?r) \Leftarrow (o3)$
- $hasUsageTransferRights(?x, ?r) \wedge delegate_t(?x, ?y) \wedge hasPrepaid(?y, ?a) \wedge \geq_1 hasTransferCount(?r) \Longrightarrow hasUsageTransferRights(?y, ?r) \Leftarrow (o4)$

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Natural Language of License Agreement

Example

Content distributor Charlie c makes an agreement with two content consumers, Alice a and Bob b. After each paying five dollars, and then both receiving acknowledgement from Charlie, Alice and Bob are given the usage rights and may each display an eBook asset, Harry Potter and the Deathly Hallows, up to five times. They may each print it only once. However, the total number of actions, either displays or prints done by Alice and Bob, may be at most ten. The usage rights validity period is between 2007/05/07/09:00 - 2007/05/10/24:00.

Abstract Syntax of License Agreement

Example

agreement
between Charlie and {Alice,Bob}
about Harry Potter and the Deathly Hallows
with inSequence[prePay[5.00],attribution[Charlie]]
$\Longrightarrow$ *not[and[Time* $<$ *2007/05/07/09:00,*
Time $>$ *2007/05/10/24:00]]* $\Longrightarrow$ *with count[10]*
$\Longrightarrow$ *and[forEachMember[Alice,Bob;count[5]]*
$\Longrightarrow$ *display, forEachMember[Alice,Bob;count[1]]*
$\Longrightarrow$ *print]*

FOL of License Agreement

Example

$$\forall x((x = Alice \vee x = Bob) \Longrightarrow \exists t_1 \exists t_2 (t_1 < t_2 \wedge Paid(5, t_1) \wedge Attributed(Charlie, t_2))) \Longrightarrow$$
$$\forall t \wedge hasDateTime(t) \geq 2007/05/07/09:00 \wedge hasDateTime(t) \leq 2007/05/10/24:00 \Longrightarrow$$
$$count(Alice, id_1) + count(Alice, id_2) + count(Bob, id_1) + count(Bob, id_2) < 10 \Longrightarrow$$
$$(count(Alice, id_1) < 5 \wedge count(Bob, id_1) < 5 \Longrightarrow \textbf{Permitted}(x, display, ebook)) \wedge$$
$$(count(Alice, id_2) < 1 \wedge count(Bob, id_2) < 1 \Longrightarrow \textbf{Permitted}(x, print, ebook)))$$

Ontologies for License Agreement

Example (Ontology for content distributor Charlie)

- $\mathit{hasDisplayRights} \sqsubseteq \mathit{hasUsageRights}$
- $\mathit{hasPrintRights} \sqsubseteq \mathit{hasUsageRights}$
- $\leq (\mathit{hasDisplayCount}_{\{a,b\}}.\mathit{eBook},\ \mathit{hasUsageCount}_c.\mathit{eBook})$
- $\leq (\mathit{hasPrintCount}_{\{a,b\}}.\mathit{eBook},\ \mathit{hasUsageCount}_c.\mathit{eBook})$
- $\{\mathit{Alice}, \mathit{Bob}\} \overset{domain}{\Leftarrow} \mathit{hasUsageRights} \overset{range}{\longrightarrow} R_1$, where $R_1 = \leq_{10} \mathit{hasUsageCount}_c \wedge \geq_{2007/05/07/0900} \mathit{hasDateTime}_c.\mathit{Time} \wedge \leq_{2007/05/10/2400} \mathit{hasDateTime}_c.\mathit{Time}$
- $\exists =_\alpha \exists = \mathit{sum}(\exists \leq_5 \mathit{hasDisplayCount}_i.\{\mathit{HarryPotter}\})$, $i \in \{a, b\}$, where α: $\exists \mathit{hasDisplayCount}_c.\{\mathit{HarryPotter}\}$
- $\exists =_\beta \exists = \mathit{sum}(\exists \leq_1 \mathit{hasPrintCount}_i.\{\mathit{HarryPotter}\})$, $i \in \{a, b\}$, where β: $\exists \mathit{hasPrintCount}_c.\{\mathit{HarryPotter}\}$
- $\exists =_\delta \mathit{sum}(\alpha, \beta)$, where $\delta : \exists \mathit{hasUsageCount}_c\{\mathit{HarryPotter}\}$

Ontologies for License Agreement

Example (Ontology for content distributor Charlie)

- $hasDisplayRights \sqsubseteq hasUsageRights$
- $hasPrintRights \sqsubseteq hasUsageRights$
- $\leq (hasDisplayCount_{\{a,b\}}.eBook,\ hasUsageCount_c.eBook)$
- $\leq (hasPrintCount_{\{a,b\}}.eBook,\ hasUsageCount_c.eBook)$
- $\{Alice, Bob\} \overset{domain}{\Leftarrow} hasUsageRights \overset{range}{\longrightarrow} R_1$, where $R_1 = \leq_{10} hasUsageCount_c \wedge \geq_{2007/05/07/0900} hasDateTime_c.Time \wedge \leq_{2007/05/10/2400} hasDateTime_c.Time$
- $\exists =_\alpha \exists = sum(\exists \leq_5 hasDisplayCount_i.\{HarryPotter\})$, $i \in \{a, b\}$, where α: $\exists hasDisplayCount_c.\{HarryPotter\}$
- $\exists =_\beta \exists = sum(\exists \leq_1 hasPrintCount_i.\{HarryPotter\})$, $i \in \{a, b\}$, where β: $\exists hasPrintCount_c.\{HarryPotter\}$
- $\exists =_\delta sum(\alpha, \beta)$, where $\delta : \exists hasUsageCount_c\{HarryPotter\}$

Rules for License Agreement

Example (Rules for content distributor Charlie)

- $hasDisplayRights(?x, ?r) \wedge hasSell_dRights(?x, ?r) \Longrightarrow hasDisplaySell_dRights(?x, ?r)$
- $hasPrintRights(?x, ?r) \wedge hasSell_dRights(?x, ?r) \Longrightarrow hasPrintSell_dRights(?x, ?r)$
- $hasDisplaySell_dRights(?x, ?r) \wedge delegate_g(?x, ?y) \wedge hasPrepaid(?y, ?a) \Longrightarrow hasDisplayRights(?y, ?r)$
- $hasPrintSell_dRights(?x, ?r) \wedge delegate_g(?x, ?y) \wedge hasPrepaid(?y, ?a) \Longrightarrow hasPrintRights(?y, ?r)$

Rules for License Agreement

Example (Rules for content distributor Charlie)

- $hasDisplayRights(?x, ?r) \wedge hasSell_d Rights(?x, ?r) \Longrightarrow hasDisplaySell_d Rights(?x, ?r)$
- $hasPrintRights(?x, ?r) \wedge hasSell_d Rights(?x, ?r) \Longrightarrow hasPrintSell_d Rights(?x, ?r)$
- $hasDisplaySell_d Rights(?x, ?r) \wedge delegate_g(?x, ?y) \wedge hasPrepaid(?y, ?a) \Longrightarrow hasDisplayRights(?y, ?r)$
- $hasPrintSell_d Rights(?x, ?r) \wedge delegate_g(?x, ?y) \wedge hasPrepaid(?y, ?a) \Longrightarrow hasPrintRights(?y, ?r)$

Facts for License Agreement

Example (Facts for content distributor Charlie)

- $eBook(HarryPotter)$
- $hasDisplayRights(Charlie, HarryPotter)$
- $hasPrintRights(Charlie, HarryPotter)$
- $hasSell_d Rights(Charlie, HarryPotter)$
- $hasDisplaySell_d Rights(Charlie, HarryPotter)$
- $hasPrintSell_d Rights(Charlie, HarryPotter)$
- $\exists =_5 hasPrepaid(Alice)$
- $hasDisplayRights(Alice, HarryPotter)$
- $hasPrintRights(Alice, HarryPotter)$
- $\exists =_5 hasPrepaid(Bob)$
- $hasDisplayRights(Bob, HarryPotter)$
- $hasPrintRights(Bob, HarryPotter)$

$\ldots \ldots \ldots$

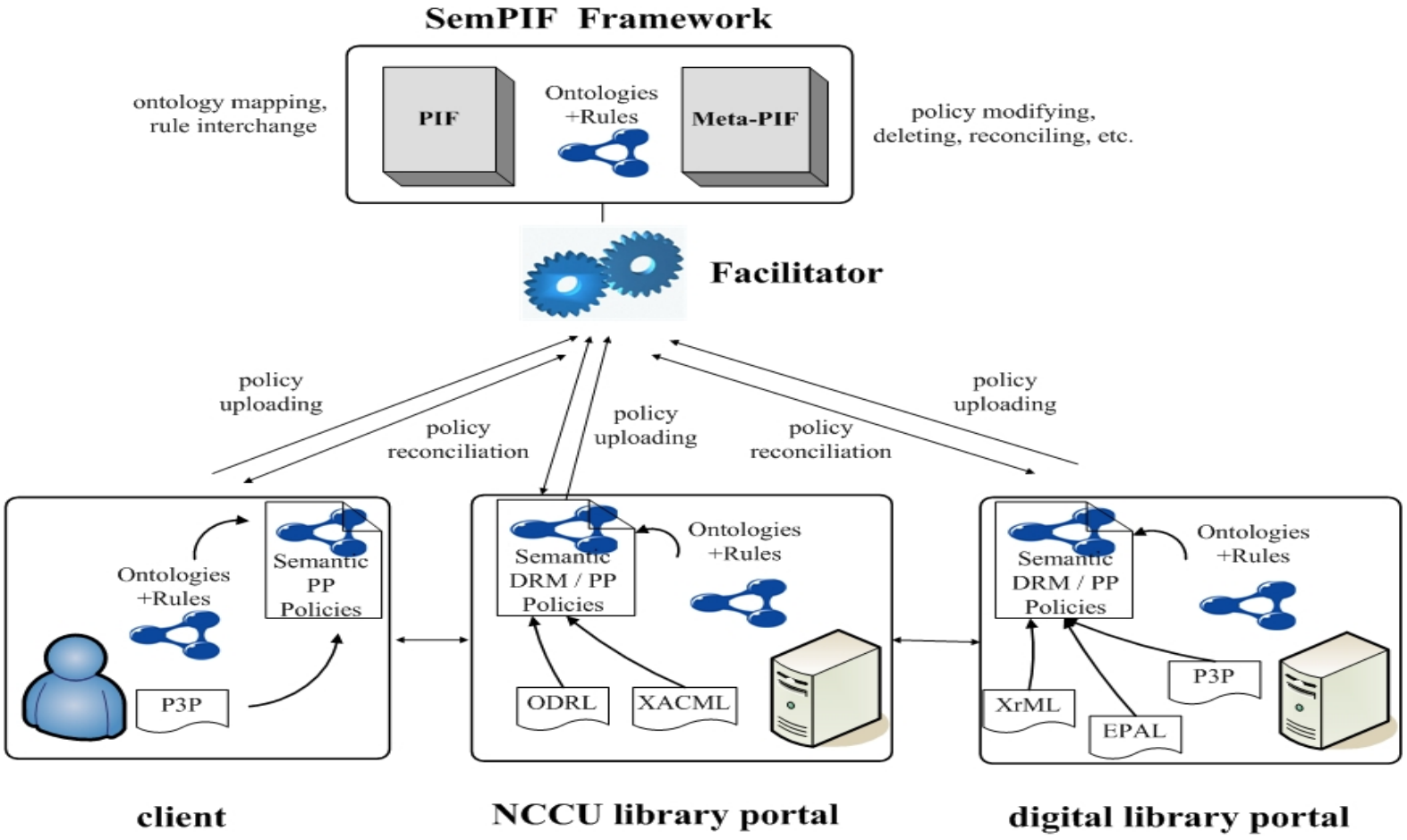
Part VI

SemPIF for DRM and Privacy Protection

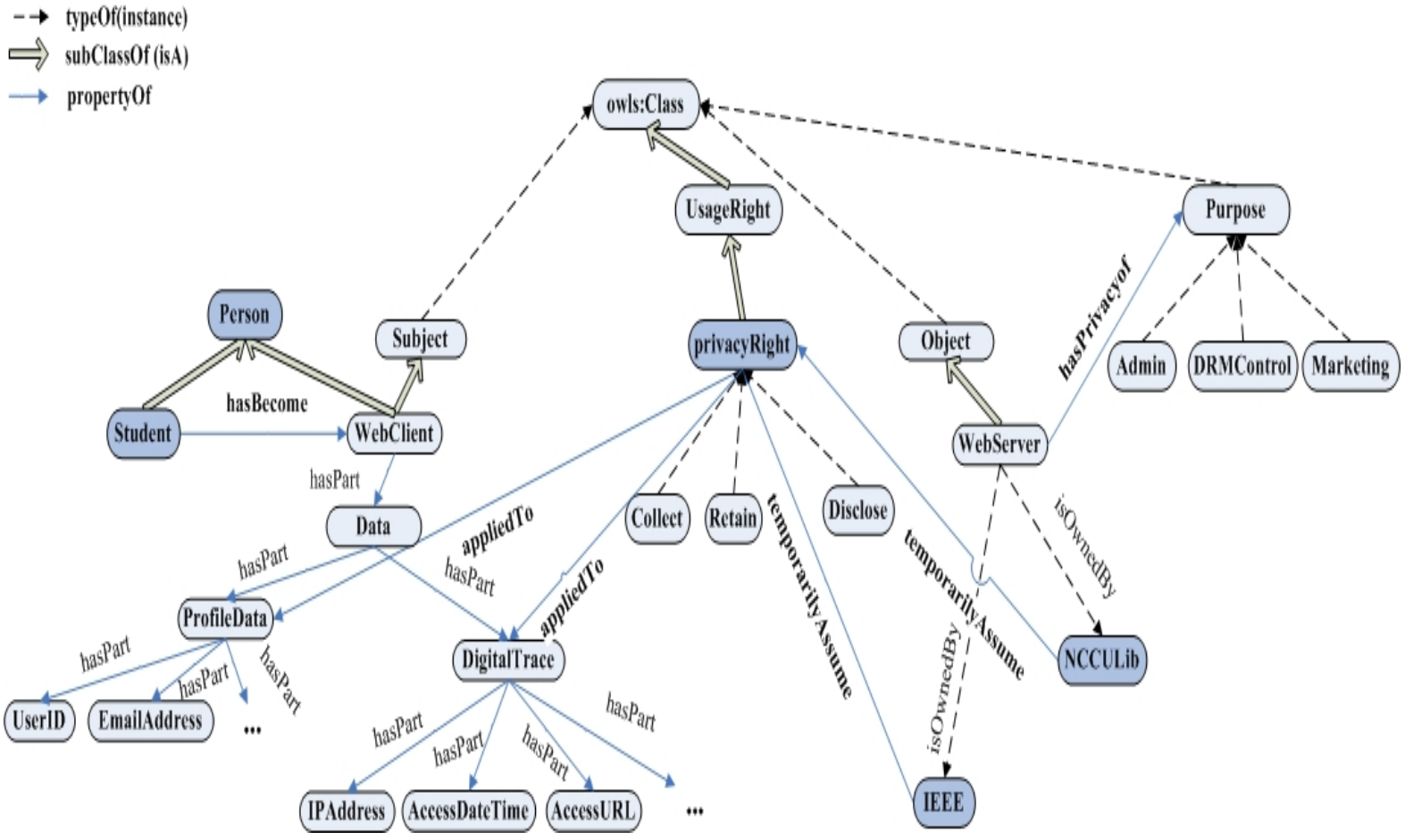
What Are the Research Issues in SemPIF?

- Policy representation and enforcement in terms of knowledge systems, e.g. ontology+rule
- Multiple Web policies interoperability and management services
- Policies conflicts resolution for agents (or facilitators) to use SemPIF architecture

SemPIF framework for a Client Server Model



A PIF-based Privacy Protection Ontology



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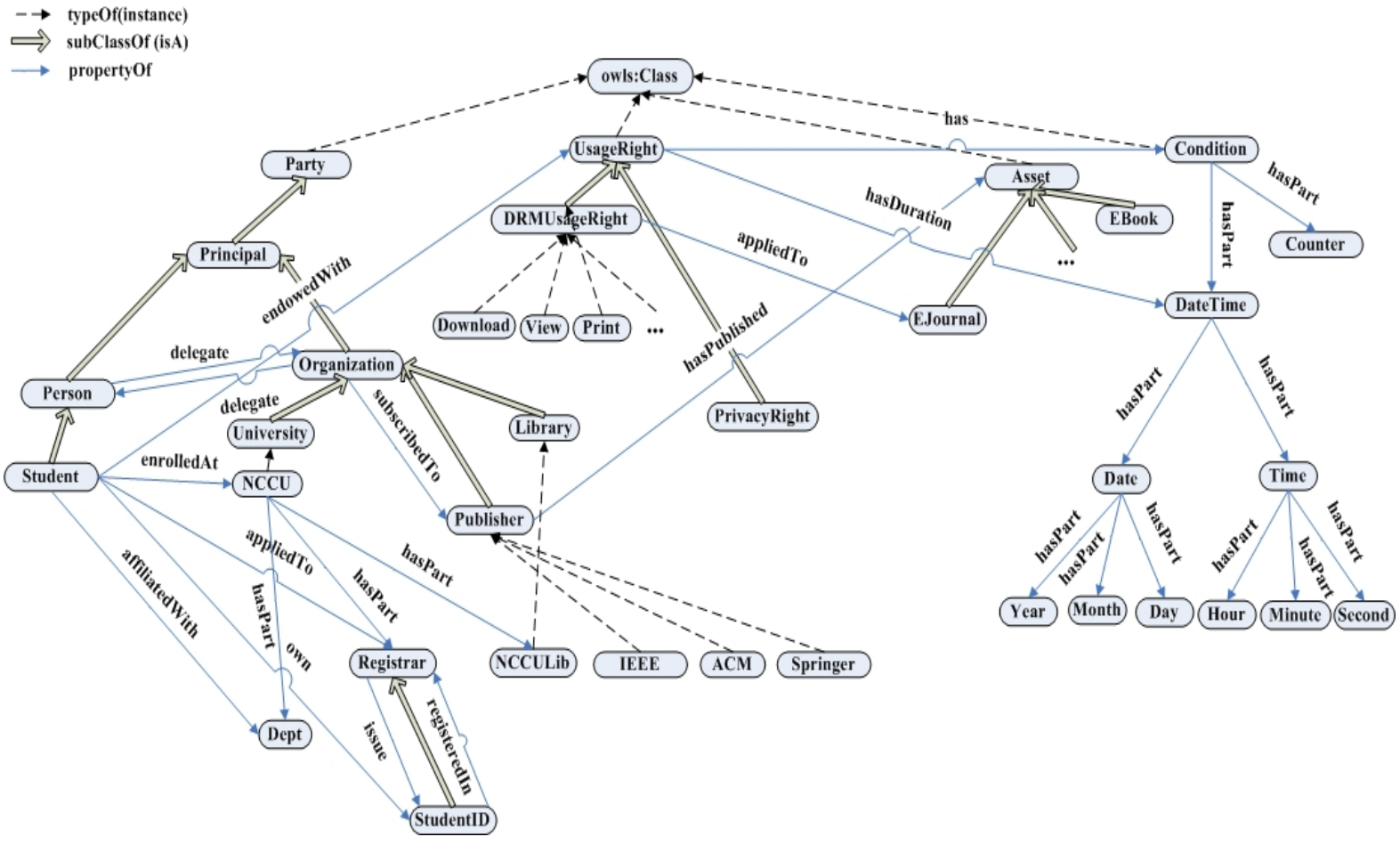

A Web Server's DRM Policy

Natural (Controlled) Language

Example (*Policy ID: drm1-IEEE*)

If a Student owns a valid student ID (StudentID) issued by the Registrar of a University and the Library of the University is one of the subscribers in the IEEE publisher list, then the student is endowed with DRM usage rights {download,view,print} of an EJournal from a Web server of the IEEE publisher.

A Web Server's DRM Policy

OWL 2+RIF

Example (*Policy ID: drm1-IEEE*)

$?st\#Student \wedge ?id\#StudentID \wedge ?uni\#University \wedge ?rg\#Registrar \wedge ?lib\#Library$
$\wedge ?ejr\#EJournal \wedge ?usrgt\#UsageRight \wedge ?st[own \longrightarrow ?id] \wedge ?uni[hasPart \longrightarrow ?rg]$
$\wedge ?st[enrolledAt \longrightarrow ?uni] \wedge ?rg[issue \longrightarrow ?id] \wedge ?uni[hasPart \longrightarrow ?lib]$
$\wedge ?lib[subscribedTo \longrightarrow IEEE] \wedge IEEE[hasPublished \longrightarrow ?ejr]$
$\wedge IEEE[endowedWith \longrightarrow ?usrgt] \wedge ?usrgt[appliedTo \longrightarrow ?ejr]$
$\Longrightarrow IEEE[delegate \longrightarrow ?st] \wedge ?st[endowedWith \longrightarrow ?d] \wedge ?st[endowedWith \longrightarrow ?v]$
$\wedge ?st[endowedWith \longrightarrow ?p] \wedge ?d\#\ Download \wedge ?d[appliedTo \longrightarrow ?ejr]$
$\wedge ?v\#View \wedge ?v[appliedTo \longrightarrow ?ejr] \wedge ?p\#Print \wedge ?p[appliedTo \longrightarrow ?ejr].$

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A Web Server's Privacy Policy

OWL2+RIF

Example (*Policy ID: pp1-IEEE*)

$$
\begin{aligned}
&?per\#Person \wedge ?usrgt\#UsageRight \wedge ?ejr\#EJournal \wedge \wedge ?prfl\#Profile \wedge ?trc\#Trace \\
&\wedge ?prrgt\#PrivacyRight \wedge ?per[endowedWith \rightarrow ?usrgt] \wedge ?usrgt[appliedTo \rightarrow ?ejr] \\
&\wedge IEEE[hasPublished \rightarrow ?ejr] \wedge IEEE[hasPrivacyOf \rightarrow DRMControl] \\
&\wedge ?per[hasPart \rightarrow ?prfl] \wedge ?per[hasPart \rightarrow ?trc] \wedge ?per[endowedWith \rightarrow ?prrgt] \\
&\Longrightarrow ?per[delegate \rightarrow IEEE] \wedge IEEE[temporarilyAssume \rightarrow ?prrgt] \\
&\wedge ?prrgt[hasDuration \rightarrow month(2)] \\
&\wedge ?prrgt[appliedTo \rightarrow ?prfl] \wedge ?prrgt[appliedTo \rightarrow ?trc] \\
&\wedge ?c\#Collect \wedge ?c[appliedTo \rightarrow ?prfl] \wedge ?c[appliedTo \rightarrow ?trc] \\
&\wedge ?r\#Retain \wedge ?r[appliedTo \rightarrow ?prfl] \wedge ?r[appliedTo \rightarrow ?trc] \\
&\wedge ?i\#Disclose \wedge ?i[appliedTo \rightarrow ?prfl] \wedge ?i[appliedTo \rightarrow ?trc].
\end{aligned}
$$

A Web User's Privacy Policy

Natural (Controlled) Language

Policy ID: pp5-John

If an EJournal Publisher **other than** *IEEE has the purpose of enforcing DRM control of collecting, retaining, and disclosing on John's data then it temporarily assumes privacy rights {collect,retain} on John's digital Traces under the condition of a retention period less than seven days.*

Policy ID: pp6-John

If the IEEE EJournal Publisher has the purpose of enforcing DRM control of collecting, retaining, and disclosing on John's data then it temporarily assumes privacy rights {collect,retain} on John's digital Traces under the condition of retention period less than fourteen days.

A Web User's Privacy Policy

Natural (Controlled) Language

Policy ID: pp5-John

If an EJournal Publisher **other than** *IEEE has the purpose of enforcing DRM control of collecting, retaining, and disclosing on John's data then it temporarily assumes privacy rights {collect,retain} on John's digital Traces under the condition of a retention period less than seven days.*

Policy ID: pp6-John

If the IEEE EJournal Publisher has the purpose of enforcing DRM control of collecting, retaining, and disclosing on John's data then it temporarily assumes privacy rights {collect,retain} on John's digital Traces under the condition of retention period less than fourteen days.

Discussion

Policy Representation and Enforcement

Natural Language

- Pros: human readable and understandable
- Cons: machine unfriendly but no formal semantics for the machine

Pure FOL

- Pros: formal and clear syntax and semantics
- Cons: machine unfriendly, possibly undecidable computation complexity, and policies writer (reader) needs to be a logician

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Discussion (conti.)

Policy Representation and Enforcement

Rights Expression Languages

- Pros: XML-based documents for machine processing
- Cons: no formal semantics for the machine

Ontology+Rule with XML Presentation Syntax

- Pros: formal semantics for automatic machine processing and understanding
- Cons: limited expressing power under certain conditions, such as negation-free, function-free, and with limited number of parameters in the Datalog

Discussion (conti.)

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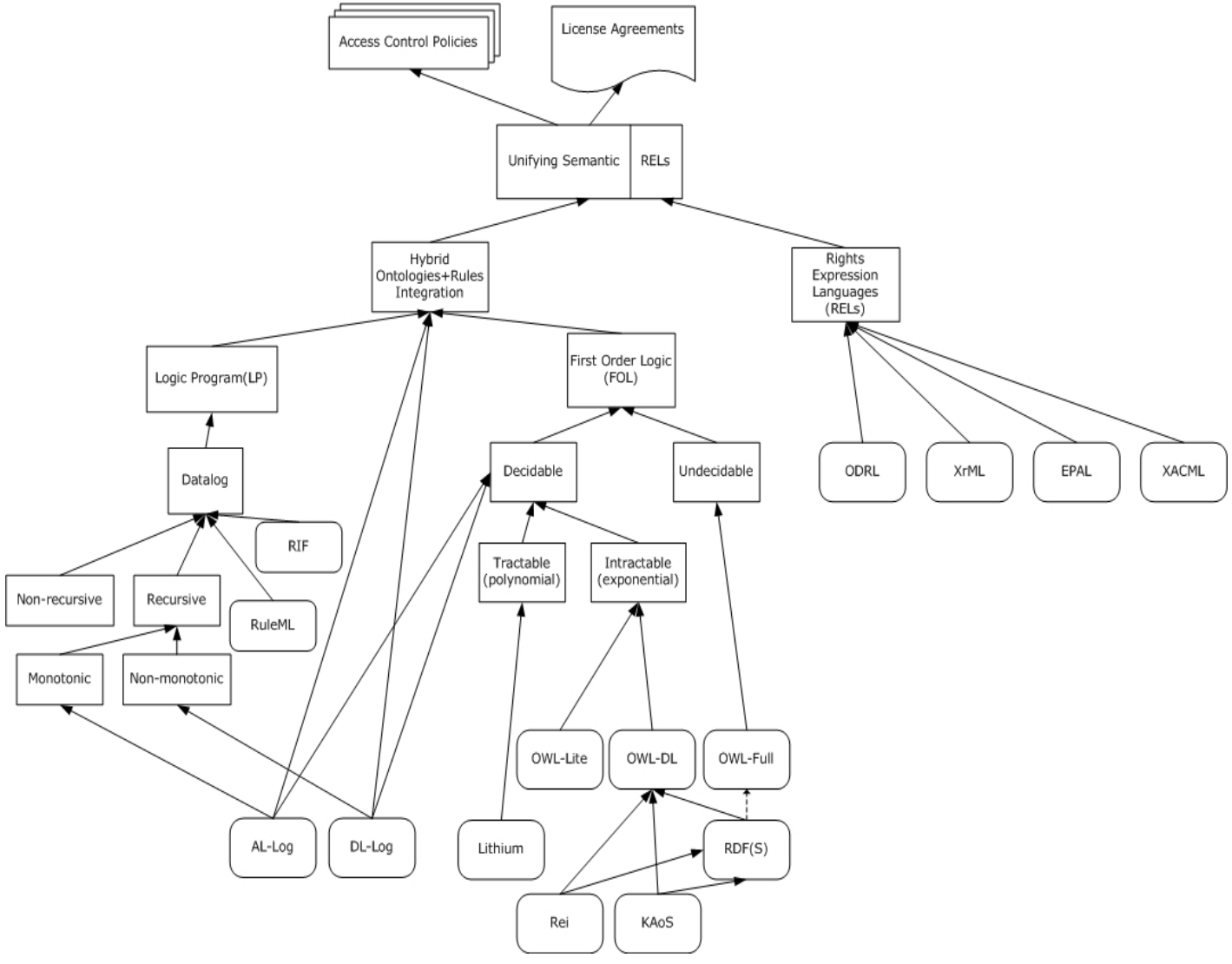
Policy Languages for Access Rights Permission



Conclusion and Future Work

- Semantics-enabled policies for DRM, privacy protection, and both
- Semantics-enabled DRM policies in terms of SWRL with ODRL.
- Semantics-enabled of privacy protection policies in terms of a combination of ontology+rule with P3P.
- SemPIF policy layered architecture is proposed for the following purposes:
  1. SemPIF extends W3C's semantic web architecture.
  2. Policy in Policy Interchange Format (PIF) is available for facilitators (or agents) to provide regular policy interchange services.
  3. Meta-policy in meta-PIF is available for facilitators (or agents) to provide the management services for PIF-based policies and regular policies in the current and future policy languages.
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