On XACML's Adequacy to Specify and to Enforce HIPAA

Omar Chowdhury[1] **Haining Chen**[2] **Jianwei Niu**[1]
Ninghui Li[2] **Elisa Bertino**[2]

University of Texas at San Antonio[1]

Purdue University[2]

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Motivation

- Organizations collect private information from their customer for performing their business operations
  - **Example**: Healthcare providers collect private health information from their patient.
- Federal regulations mandate how the collected information can be used or disclosed
  - **Example**: Health Insurance Portability and Accountability Act (**HIPAA**), Gramm-Leach-Bliley Act (**GLBA**), *etc.*
- Violations of these regulations can bring down heavy financial penalties and sanctions for the organizations
- Violations might also be harmful to the organizations' reputation

The Problem

- Researchers have proposed formalism to completely specify privacy regulations like **HIPAA**
- Organizations intended to enforce privacy regulations will have their own access control policies and business privacy policies
- Using different formalisms to capture each of these policies is cumbersome
- An action can be regulated by all of the policies of the organization
- Have to combine the decisions of the different policies manually

The Current Work

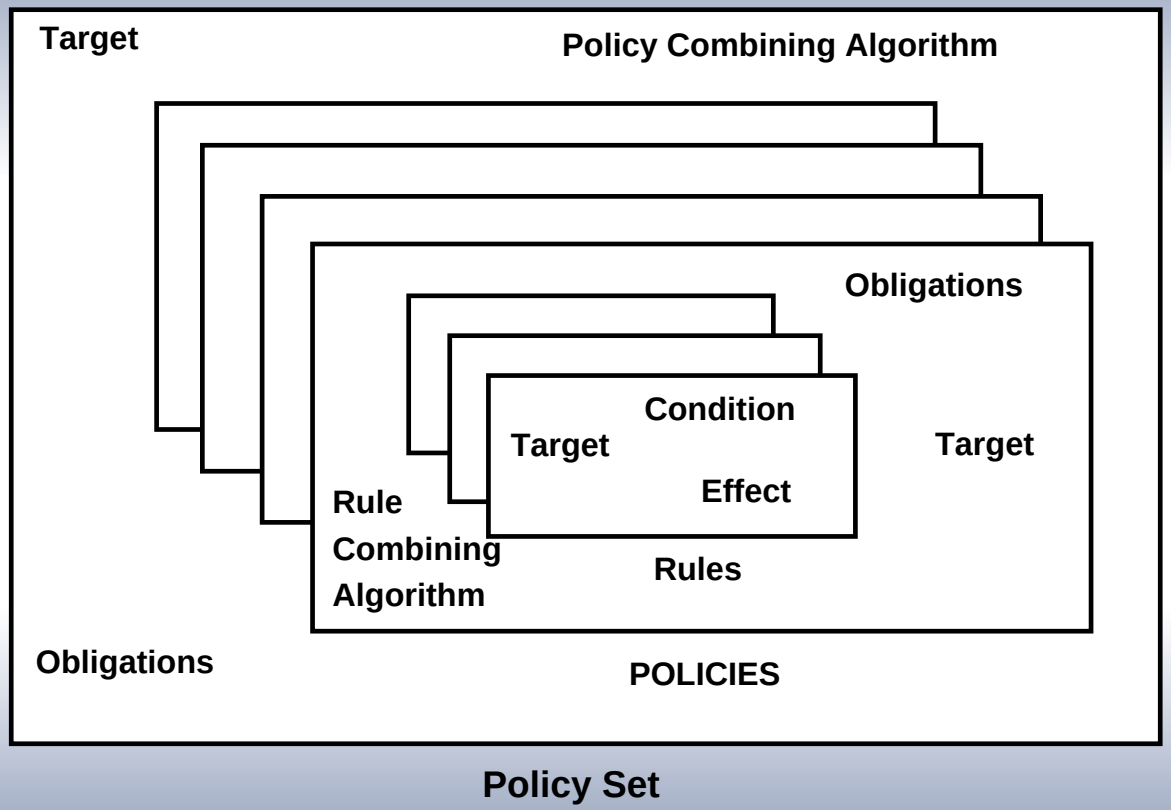
- OASIS's eXtensible Access Control Markup Language (**XACML**) is a widely used access control formalism in both industry and academic research
- The current work evaluates the adequacy of **XACML**'s specification language and enforcement engine to specify and enforce **HIPAA**
- **XACML** has some rich enough features
  - **Example**: attributes, policy/policy rule combination, *etc.*
- **XACML** naturally lacks some features to support **HIPAA**
  - **Example**: event history, obligations, subjective beliefs, *etc.*
- We present high level designs to extend **XACML** with the missing features

Outline

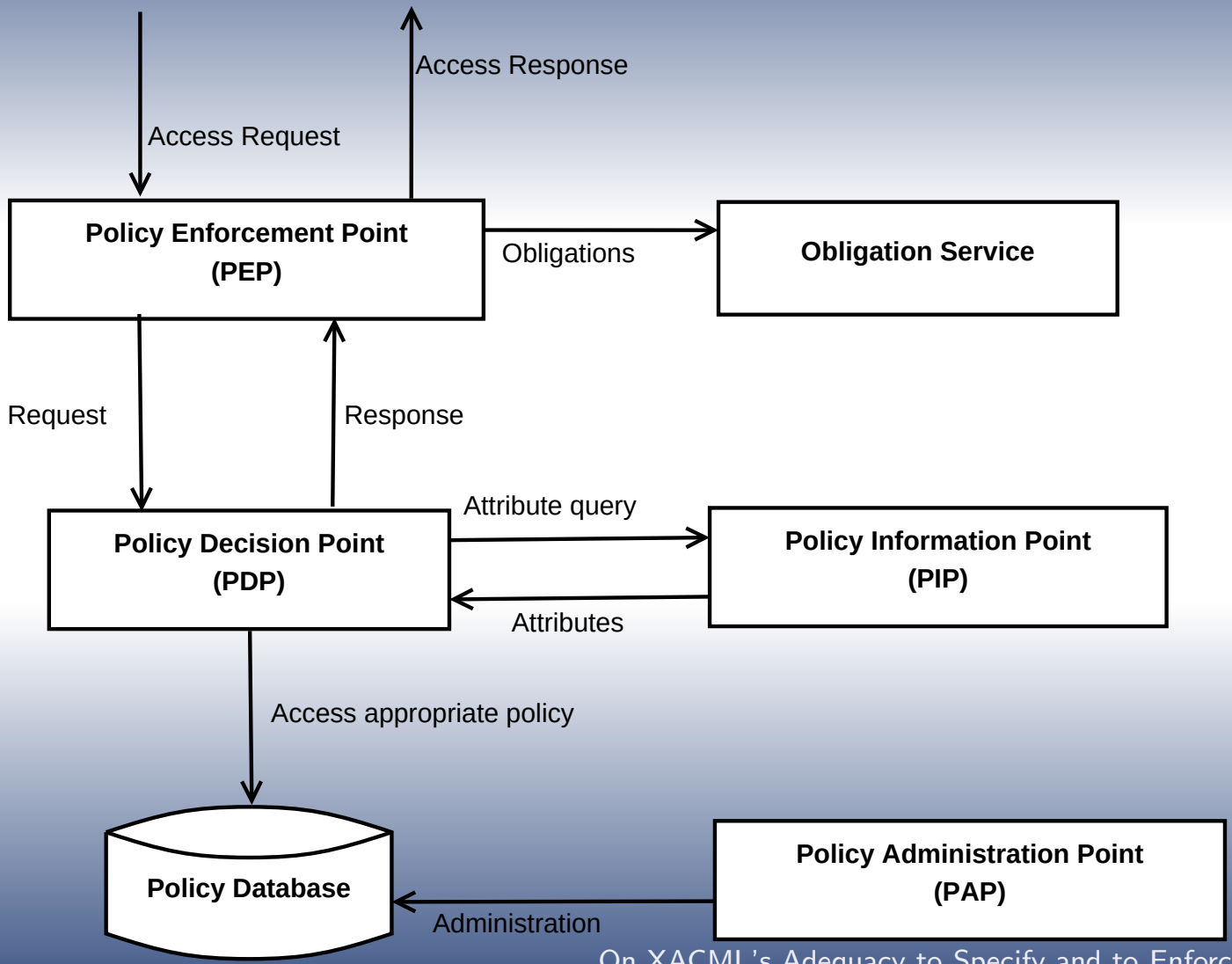
HIPAA

- **HIPAA** privacy regulations ensure that the consumers can access their health information and also make sure their information is protected from unauthorized disclosure
- It mandates the usage or disclosure of patient's *protected health information* by the *covered entities*
  - **Example:** health plans, health care providers, healthcare clearing houses, *etc.*
- *Protected health information* (*phi*) refers to the individually identifiable health information
- The purposes of a usage or disclosure *phi* is also regulated by **HIPAA**
- The role of the entity to whom the disclosure is made is also regulated by **HIPAA**

eXtensible Access Control Markup Language (XACML) Specification Language



eXtensible Access Control Markup Language (XACML) Enforcement Architecture



Outline

Necessary Features for HIPAA

- **Attributes**: sender, receiver, subject, message
  - §**164.502(a)(1)(i)**: a covered entity is permitted to use or disclose *phi* to the individual
- **Attribute Inference Policy**: it regulates whether a principal has a particular attribute based on his current attributes
  - §**164.502(g)(2)**: under what conditions a principal is considered another individual's personal representative
- **Past Events**: past events can influence the permissibility of an action
  - §**164.502(e)(1)(i)**: a covered entity can disclose *phi* to its business associate provided that it has received satisfactory assurance about safeguarding the information

Necessary Features for HIPAA (contd.)

- **Obligations**: the regulations can also impose obligatory requirements
  - §**164.524(b)(2)(i)**: a covered entity must act on a request for access no later than 30 days after receiving the request
- **Purpose**: purpose of an action can also influence its permissibility
  - §**164.506(c)(1)**: a covered entity may use or disclose *phi* for its own treatment, payment, or health care operations
- **Subjective Beliefs**: a subject's judgement can influence permissibility of an action
  - §**164.512(f)(5)**: a covered entity can disclose *phi* to a law enforcement official if he thinks it can be used as evidence
- **Reference to Other Laws/Rules**: the regulations can refer to other laws or rules
  - §**164.512(a)(1)**: a covered entity may use or disclose *phi* when it is required by other law

Assumptions

- The actions we consider are: *disclose*, *request*, *use*, and *access*
- We only regulate communication messages containing *phi* of an individual
- The sending principal provides the purpose of the transmission
- It is the responsibility of the sending principal to tag the message with its appropriate attributes
- Any incurred obligations are consistent with the policies
- Patient policies are consistent with **HIPAA**
- We assume there exists an oracle that makes some decision about some request
    - Example: whether certain action is prohibited by any applicable law

Outline

Stateful Policies vs. Stateless Mechanism

- **XACML** policies are largely stateless
- The enforcement mechanism of **XACML** is also stateless
- Any stateful information is kept outside the policy engine
- The **HIPAA** privacy rules are stateful
- The enforcement mechanism for the **HIPAA** privacy rules needs to be stateful too
- The reason for **HIPAA** requiring stateful mechanisms are:
  - Obligations
  - Event history
  - Policy-directed attribute retrieval
  - Policy-directed policy retrieval

Interactive vs. Non-interactive Policy Evaluation

- **XACML**'s policy evaluation is non-interactive
- However, it seems for **HIPAA** an interactive policy evaluation is needed
- The necessity for the interactive policy evaluation:
  - Subjective beliefs
  - Reference to other policy rules and laws
- Determining them from the static context of a request is not always feasible

Other Considerations

- Attribute inference policy vs. privacy rules
  - A disclosure or usage is allowed when the receiver is patient's personal representative
  - **Example**: is principal p a personal representative of the principal q?
- Quantification over the infinite domains
  - Quantification is needed for concise policy specification
  - Domains are: principals, message attributes, messages, *etc.*
  - **Example**: a disclosure is allowed if the sender received a message containing the authorization before
  - **XACML**'s specification language does not support quantification explicitly

Outline

HIPAA Privacy Rules

- Required privacy rules and permitting privacy rules
- Permitting privacy rules are divided into two more types
  - Allowing and prohibitive privacy rules
- Each privacy rule can regulate the following:
  - Sender's, recipient's, and subject's attributes (*e.g.*, role, *etc.*)
  - Purpose of the disclosure (*e.g.*, treatment, payment, *etc.*)
  - The message attributes (*e.g.*, *phi*, ssn, psychotherapy-notes *etc.*)
  - Obligations
  - Event history
  - Other conditions

Extensions

- Obligations
  - We use the obligation model of Li *et al.* 2010
  - An obligation is modeled as a state machine that changes state with respect to events
  - PEP keeps track of the obligations' state
- Event history
  - We propose a "history manager"
  - Relation database that keeps track of the important events
  - Manually inspect the policy to decide which events to store in the history manager
  - **Example**: A covered entity can disclose the *phi* if it has received a court-order
- Interaction with users and the oracle
  - Get information about subjective beliefs
  - Obtain information that is not present in the state (*e.g.*, reference to other laws, *etc.*)

Details of Extensions

<PolicySet> := *<Target>*<*Policy*>$^+$[*Obligations*]
Attributes: PolicySetId, PolicyCombiningAlgId
<Policy> := *<Target>*<*Rule*>$^+$[*Obligations*]
Attributes: PolicyId, RuleCombiningAlgId
<Rule> := [*Target*][*Condition*]
Attributes: RuleId, Effect

<Policy> := [*RequiredAttributeList*]*<Target>*<*Rule*>$^+$[*Obligations*]
Attributes: PolicyId, RuleCombiningAlgId
<RequiredAttributeList> := *<RequiredAttributeSelector>*$^+$
<RequiredAttributeSelector> := [*Keys*]
Attributes: AttributeId, DataType, Source,
DatabaseId (optional), TableId (optional)
<Source> := "User" | "Database" | "Oracle"
<Keys> := *<Key>*$^+$
<Key> := *<KeyValue>*
Attributes: KeyId

Details of Extensions (contd.)

<Condition> := *<Expression>*

The <Expression> element substitution group includes:
<AttributeSelector>, *<AttributeValue>*, *<VariableReference>*,
<ActionAttributeDesignator>, *<ResourceAttributeDesignator>*, *<Function>*,
<SubjectAttributeDesignator>, *<Apply>*, *<EnvironmentAttributeDesignator>*,
<**EventSelector**>

<EventSelector> :=
Attributes: EventType, EventField, DataType

Details of Extensions (contd.)

<*Condition*> := <*Expression*>

The <Expression> element substitution group includes:
<*AttributeSelector*>, <*AttributeValue*>, <*VariableReference*>,
<*ActionAttributeDesignator*>, <*ResourceAttributeDesignator*>, <*Function*>,
<*SubjectAttributeDesignator*>, <*Apply*>, <*EnvironmentAttributeDesignator*>,
<**EventSelector**>, <**AttributeInferencePolicyReference**>

<*AttributeInferencePolicyReference*> := <*Input*>$^{+}$
Attributes: AttributeInferencePolicyId

Extension for handling attribute inference policy

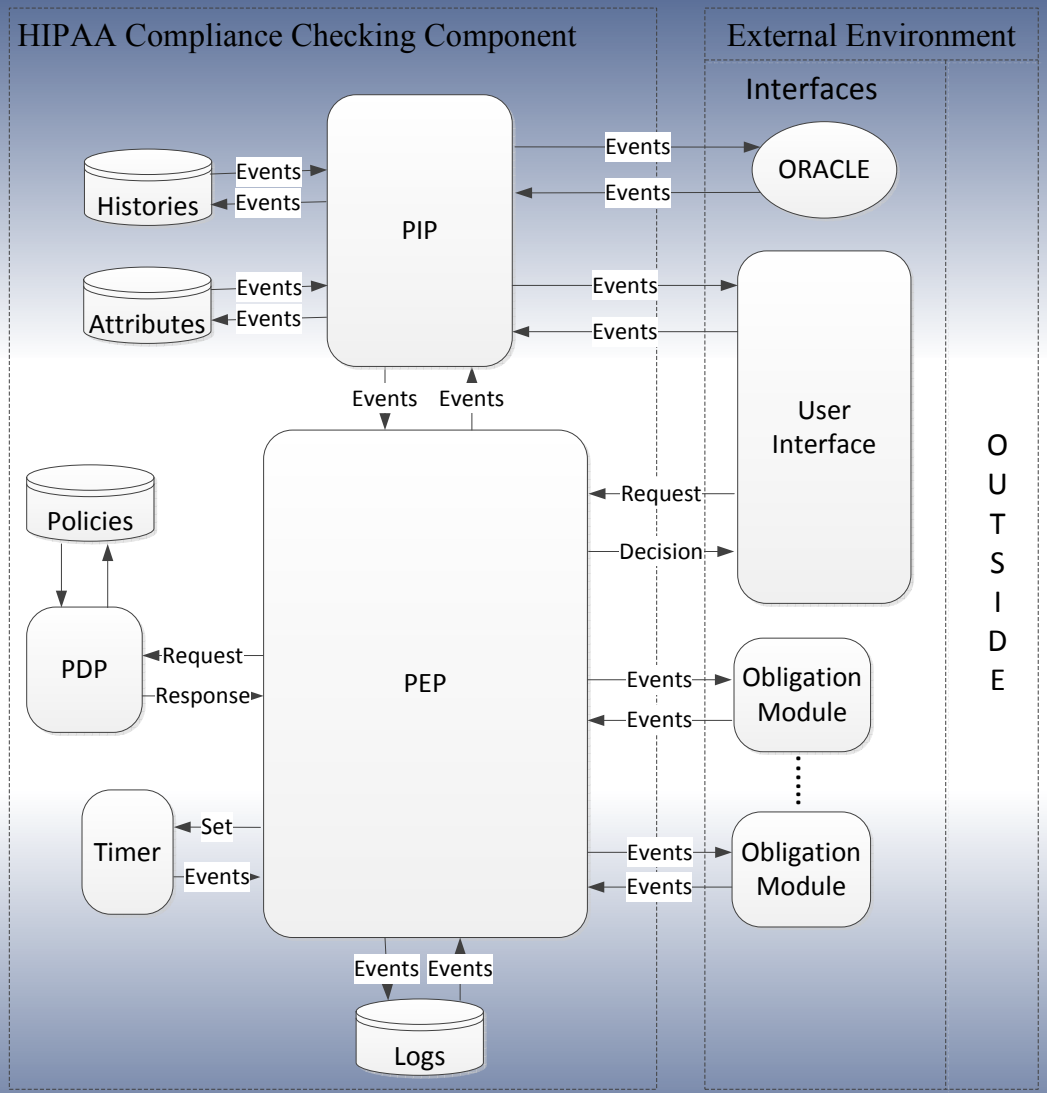
Additional Policies

- Organizational access control policies
  - Only the assigned doctors and nurses can access the *phi* of the patient
  - It must be consistent with the **HIPAA** privacy rules
- Patient policies
  - According to **HIPAA** §164.522, a covered entity can agree or disagree to comply with a patient's policy
  - When it agrees to comply with the patient policy, it has to satisfy the patient policy
  - The patient policies must be consistent with the **HIPAA** privacy rules

Policy Combination

- Required policy rules are combined using **Permit-override**
- Allowing policy rules are combined using **Permit-override**
- Prohibitive policy rules are combined using **Deny-override**
- Permitting policies are combined using **Deny-override**
- Required policies and Permitting policy is combined using **Permit-override**
- Combining additional policies:
  - **Ordered-deny-overrides** policy combination algorithm is used
  - Policies are ordered in the following order: access control policy, patient policy, HIPAA policies

Extended XACML Enforcement Architecture



Related Work

- Tschantz *et al.* 2012: Enforcing the purpose restrictions in the privacy policies
- Garg *et al.* 2011: Formalized HIPAA and present an incremental auditing algorithm
- DeYoung *et al.* 2010: Formalized HIPAA and GLBA in the logical specification language PrivacyLFP
- Lam *et al.* 2009: Formalized HIPAA in a datalog based specification language pLogic
- May *et al.* 2006: Formalized HIPAA in HRU based specification language Privacy API and performed analysis
- Barth *et al.* 2006, 2007 : Formalized HIPAA and GLBA in the first order linear temporal logic (FOTL)
- Breaux *et al.* 2005, 2006, 2008: Tool support for formalizing legal regulations as requirements

Conclusion

- We evaluate **XACML**'s adequacy to specify and enforce **HIPAA**
- **XACML** has some rich enough features
- **XACML** lacks some features for **HIPAA**
- We present high level designs for extending **XACML** to support **HIPAA**
- **Future work**:
  - Develop a prototype with the proposed extensions
  - Relax some of the restrictions

Questions?

Thank you for your attention