

A Quality of Context-Aware Approach to Access Control in Pervasive Environments

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The Second International ICST Conference on
Mobile Wireless Middleware, Operating Systems, and Applications
Berlin, 28 April 2009



Outline

- 1 Quality of Context-Aware Access Control
 - Context-Aware Access Control
 - Quality of Context
- 2 The Proteus Middleware
 - Proteus QoC-Aware Policy Model
 - Policy Management in Proteus
 - Proteus Middleware Architecture & Implementation
- 3 Conclusions & Ongoing Work
 - Summary
 - Thank you



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Context-Aware Access Control Policies

Example

In case of emergency, any qualified physician located within the hospital is allowed to access Alice's health protected information.

- Access control policies
 - ▶ High level directives defining *who* can access *which resource* under *which circumstances*
- Traditional policies based on identities/roles – static
- **Context-aware** access control policies
 - ▶ Definition of policies based on context
 - ▶ Use of semantic technologies to represent & reason about policies and contexts



Why We Need Quality of Context

- Context information determines behavior & strategies of context-aware security systems
- But is context information *reliable* itself?
 - ▶ Unknown – no available sensor information
 - ▶ Ambiguous – conflicting information from different sources
 - ▶ Imprecise – information with insufficient granularity
 - ▶ Erroneous – sensed or aggregated context not coherent with real situation
- Need to explicitly consider the **quality of context** used in security decisions



QoC Awareness & Security – State of the Art

- 1 QoC representation
 - ▶ Declarative models (QoC metadata)
 - ▶ Logical models (e.g., FOL, fuzzy logics)
 - ▶ Probabilistic models
- 2 QoC calculation techniques
 - ▶ Learning techniques and sensor training (e.g., to calculate precision & correctness)
 - ▶ Algorithms to calculate QoC value of aggregated contexts
 - ▶ Algorithms to deal with uncertain/ambiguous contexts (conflict resolution)
- 3 Few context-aware architectures explicitly consider QoC
 - ▶ Impact of QoC on context-aware security has not been thoroughly analyzed yet



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Proteus Context & Policy Model

- Proteus policies associate resources to *protection contexts*
- A protection context is a set of attributes & constrained values (*context elements*)
- The current state is a set of attributes & values measured by "sensors" (*context assertions*)
 - ▶ A protection context is *active* if context assertions describing the current state match its context elements
- Activation of protection contexts (and associated policies) allows access to a resource



Context & Policy Representation

Example

In case of emergency, any qualified physician located within the hospital is allowed to access Alice's health protected information.

PersonalEmergencyContext \equiv

ProtectionContext $\sqcap \exists$ owner.Alice $\sqcap \exists$ requestor.InHospitalQualifiedPhysician \sqcap
 \exists resource.AliceHPI $\sqcap \exists$ environment.PersonalEmergency

\langle *Dr.Green, located, EmergencyRoom* \rangle

\langle *CurrentState, environment, PersonalEmergency* \rangle

- Context & policy representation based on Description Logic



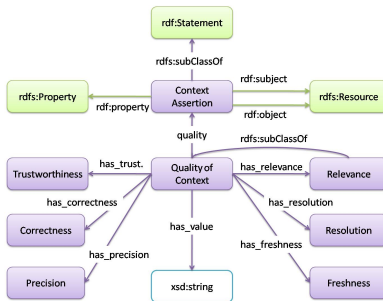
Quality of Context Model

- Proteus associates a *quality attribute* to contexts and policies
- Each quality attribute includes a numerical value and several sub-attributes:
 - ▶ freshness, precision, correctness, trustworthiness, relevance, resolution
- ① Context elements are associated to constraints on quality attributes (in addition to constraints on context attribute values)
 - ▶ Context assertions are associated to a certain value of quality attribute(s) (in addition to values for context attributes)
- ② Policies are also associated to QoC constraints (thresholds)



QoC Representation Model

- QoC constraint representation → DL + extension to RDF reification
 - ▶ Integrated with Proteus v1.0 – uniform context/policy representation (DL)
 - ▶ Compatible with existing DL/RDF reasoners – compliant with RDF model



QoC-based Context Filtering

Example

Any context assertion about the property "located" must be provided with a quality value of 0.8 or above.

$$\text{QoC_constraint} \equiv \text{CtxAssert} \sqcap \exists \text{ quality.QoC_over0.8} \sqcap \exists \text{ rdf:property.\{located\}}$$

- Proteus filters out all context assertions (describing the current state) whose quality level does not satisfy quality constraints
- Context element filtering might depend on context sources and application domain – coarse-grained (from a security perspective)
 - ▶ Reducing the number of context assertions improves efficiency
 - ▶ Only "reliable enough" context assertions are considered to take security decisions

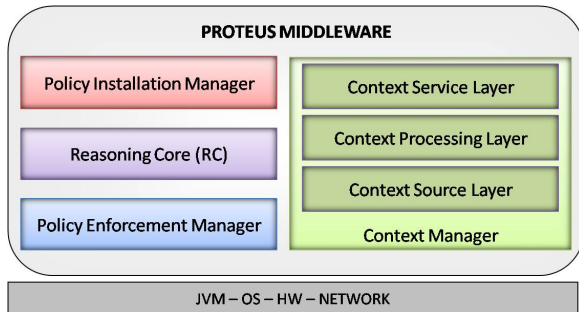


QoC-based Policy Evaluation

- Policies are assigned a quality threshold
- Current states are provided with different quality values (combining quality values of single context assertions)
- Proteus activates only policies matched by a current state that
 - 1 matches the policy protection context AND
 - 2 has a quality value higher than the policy threshold
- Policy thresholds might depend on sensitivity of the accessed resource, type of action, owner/requestor security properties
 - ▶ Variable levels of security can be obtained by adjusting quality thresholds



Proteus Middleware Architecture

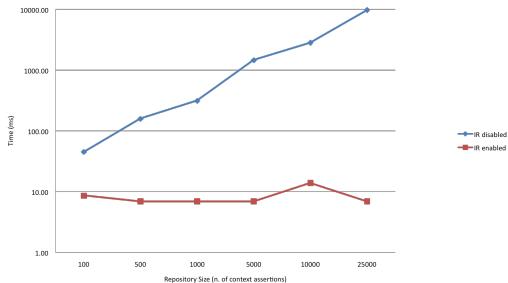


- OWL-DL to represent contexts and policies
- Java first prototype extended to support QoC
 - ▶ Pellet 1.5 DL reasoner with incremental reasoning, via OWL API & SPARQL
 - ▶ Contory Context Source & Proteus Context Service modules



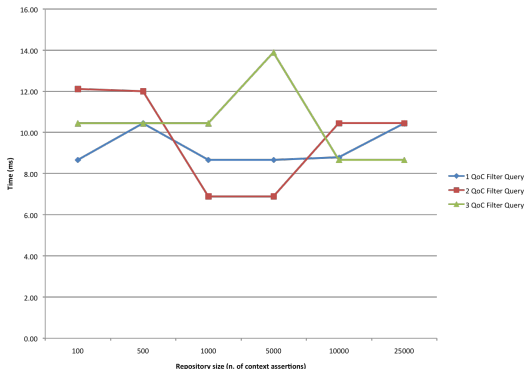
Prototype Evaluation – Context Repository Update

- Improved performance with Pellet incremental reasoning
 - ▶ Times to add context assertions show little dependence on repository size
10 ms with 25k stored context assertions
 - ▶ No real advantage in context assertion removal



Prototype Evaluation – Context Query

- QoC constraints reduce query response time by limiting the number of retrieved context assertions
 - ▶ QoC-constrained queries not dependent on repository size
→ increased efficiency



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Summary

- Proteus is a QoC-aware access control framework
 - ▶ QoC modeling & reasoning explicitly account for QoC impact on security
 - ▶ QoC improves efficiency by discarding unreliable context information

- Ongoing & Future Work
 - ▶ QoC/context information management & storage optimizations
 - ▶ Integration with existing QoC calculation frameworks/techniques
 - ▶ Evaluation of usability of the proposed approach

