Semantic security framework and context-aware role-based access control ontology for Smart Spaces

Semantic Big Data Workshop, ACM SIGMOD 2016 Conference 2016,
San Francisco, California, July 1st 2016

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Introduction

- Smart Spaces
- Security, Privacy and Context Awareness in Smart Spaces

Contribution

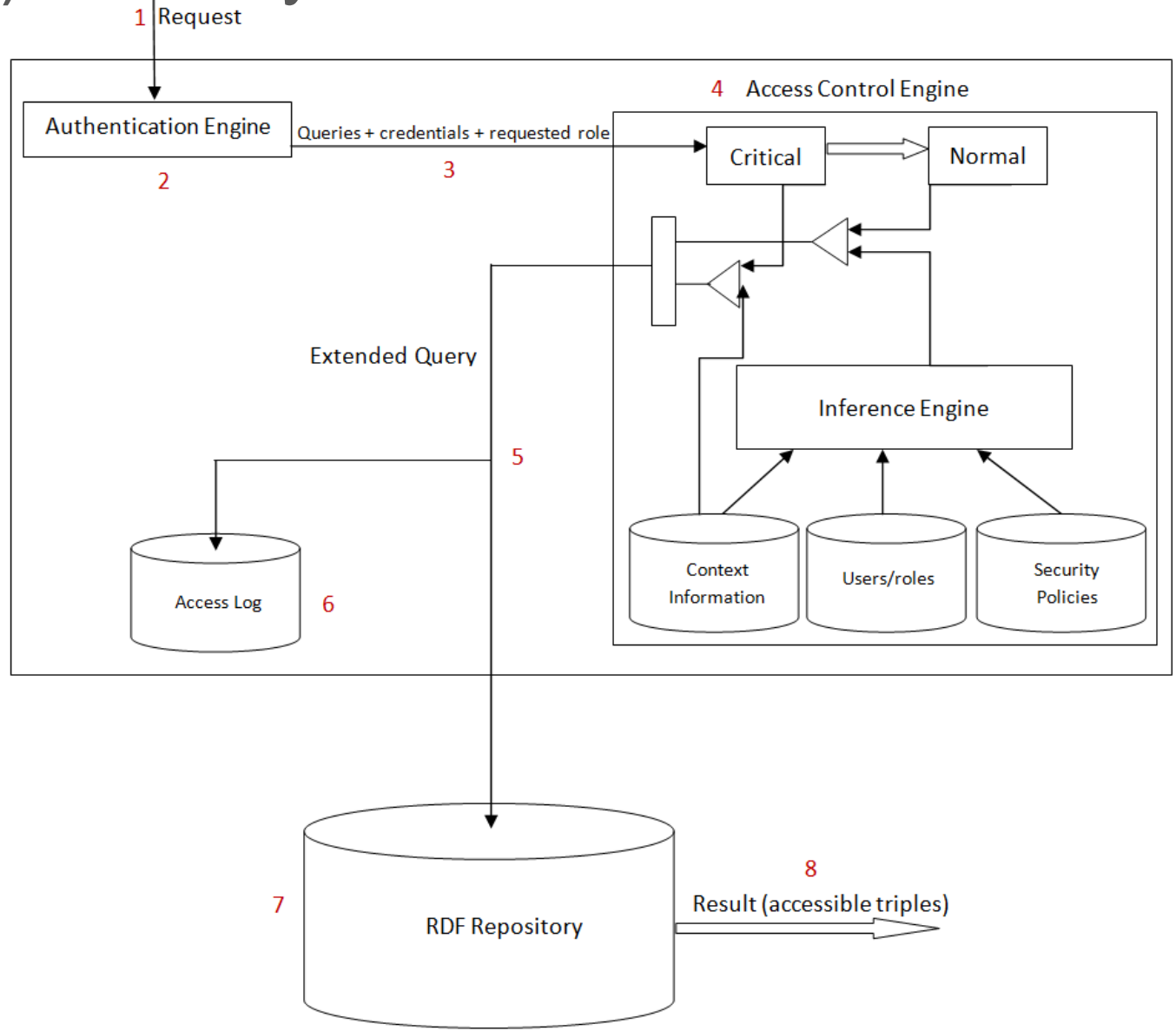
Granular triple-level mechanisms for security and privacy in Smart Spaces

1. Security framework for Smart-M3 platform [13]
2. Context-aware role-based access control scheme

Smart-M3

- Smart-M3 is a functional platform that provides a cross domain search extent for triple based information. Smart-M3 enables smart cross domain applications that rely on information level interoperability.
- Multi Device, Multi Platform, Multi Part
- https://sourceforge.net/projects/smart-m3/

1) Security framework architecture

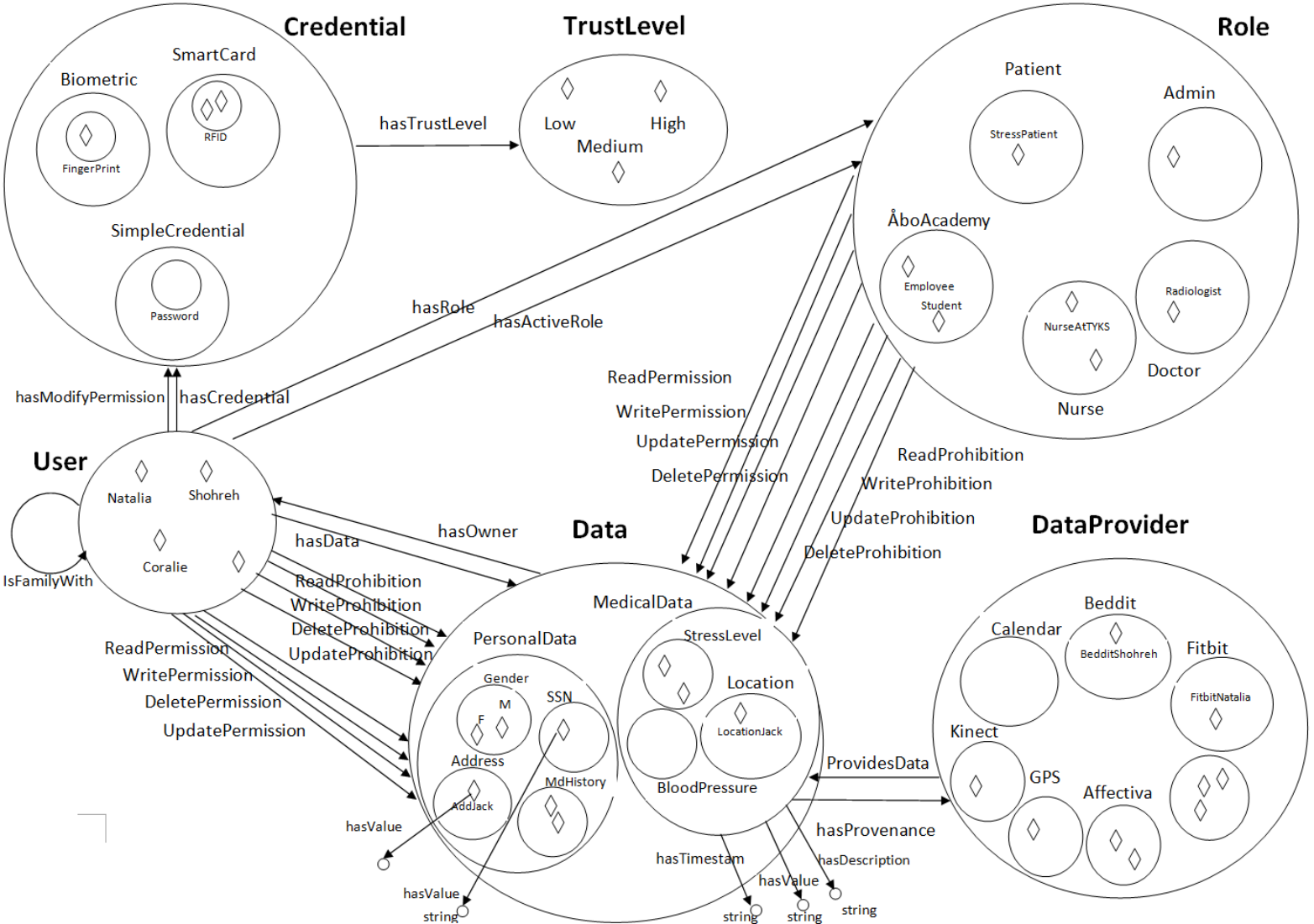


Security aspects supported:
Authentication, Authorization and Access control

Different steps:

(1) Access request from user
(2) Authentication engine assures authenticity
(3) If positive, request forwarded to Access Control Engine
(4) Execute access control rules: check if requester has rights to perform the requested action
(5) If positive the request is forwarded to the repository and access log
(6) The access log keeps record of the recent accesses.
(7) The result (accessible triple) is retrieved from the repository
(8) The result is sent to the user

2) Context Aware Role Based Access Control (CARBAC) ontology



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Comparison of access control ontologies and their Smart Space domains

Reference & Access control model	Context aware	Rule-based	Domain	Privacy control	Triple level control
[22] Context-based	✓	✓	Pervasive Computing Environments	×	×
[14] Privacy-centric	×	✓	Heterogeneous administrative medical domains	✓	✓
[7] CoBrA, No access control ontologies	✓	✓	Context-aware systems and SS	✓	×
OWL-S Services[1] Ontology-based	×	✓	Semantic Web services	✓	×
[20] OPO Access Control List (ACL)	×	✓	Linked Data	✓	✓
[16] User Behavior and Capability Based Control Access	✓	✓	Smart Spaces	✓	×
[4] Credential-based	✓	✓	XACML and SAML-based systems	✓	×
[19] SitBAC	✓	✓	Smart Spaces	✓	×
[23] Proteus, Context-centric	✓	✓	Pervasive Environments	×	×
[10] ROWLBACK	×	✓	Dynamic Environments	×	×
This work: CARBAC	✓	✓	Health and well-being SS	✓	✓

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Access Control Policies

- Expressed via rules
- At run-time, rules are executed, and decisions made on permission/prohibition of performing an action.
- For writing the access control rules, we used C Language Integrated Production System (CLIPS) v6.24
- 2 kinds of Access Control rules, defined by:
    a) Admin
    b) User for privacy protection purposes.

Example 1: Rules defined by the admin

(triple (Jack, *hasRole*, Doctor))

(triple (Maria, *hasRole*, Patient))

(triple (Maria, *hasMedicalHistory*, ?h)))

➔

(assert (triple (Jack, *roleHasReadPermissionOverData*, ?h)))

(assert (triple (Jack, *roleHasWritePermissionOverData*, ?h)))

(assert (triple (Jack, *roleHasUpdatePermissionOverData*, ?h)))

(assert (triple (Jack, *roleHasDeletePermissionOverData*, ?h)))

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Example 2: Rules defined by the user (highest priority)

(assert (triple (Jack, *userHasReadPermissionOverData*, ?h)))

(assert (triple (Jack, *userHasUpdatePermissioOverData*, ?h)))

(assert (triple (Jack, *userHasDeletePermissionOverData*, ?h)))

(assert (triple (Jack, *userHasWritePermissionOverData*, ?h)))

(assert (triple (Jack, *userHasUpdateProhibitionOverData*, ?h)))

(assert (triple (Jack, *userHasDeleteProhibitionOverData*, ?h)))

(assert (triple (Jack, *userHasWriteProhibitionOverData*, ?h)))

➔

(assert (triple (Jack, *roleHasReadPermissionOverData*, ?h)))

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Example 3:
Context aware access control rules

Doctor: restricted to only read the medical history of the patients outside the hospital, but cannot update/delete/write:

(triple (Jack, *hasRole*, Doctor))

(triple (Maria, *hasRole*, Patient))

(triple (Maria, *hasMedicalHistory*, ?h)))

(triple (LocationJack, *hasValue*, TrainStation))

➔

(assert (triple (Jack, *roleHasReadPermissionOverData*, ?h)))

(assert (triple (Jack, *roleHasWriteProhibitionOverData*, ?h)))

(assert (triple (Jack, *roleHasUpdateProhibitionOverData*, ?h)))

(assert (triple (Jack, *roleHasDeleteProhibitionOverData*, ?h)))

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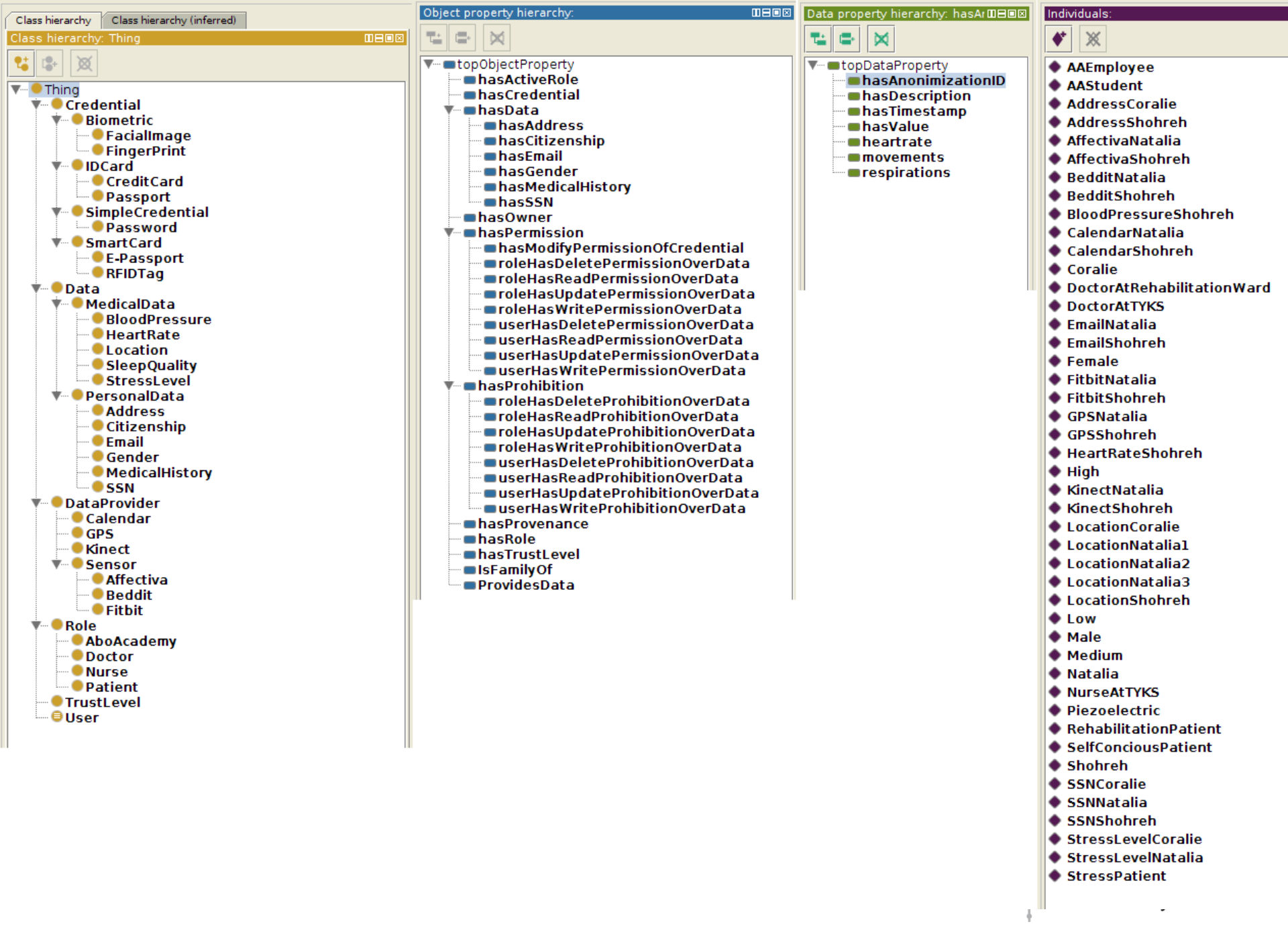
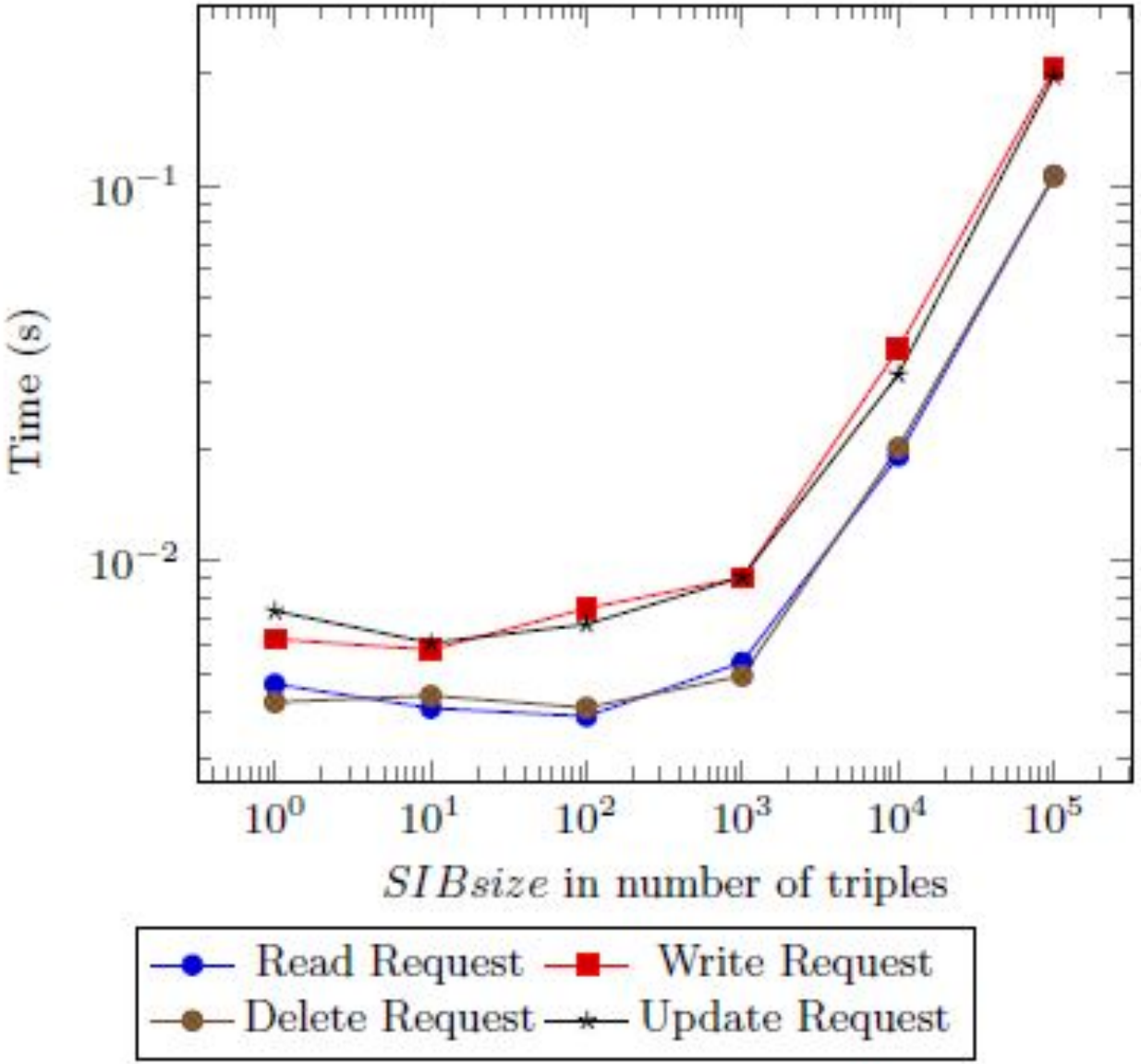

Class hierarchy
Class hierarchy (inferred)
Class hierarchy: Thing
Thing
Credential
Biometric
FacialImage
FingerPrint
IDCard
CreditCard
Passport
SimpleCredential
Password
SmartCard
E-Passport
RFIDTag
Data
MedicalData
BloodPressure
HeartRate
Location
SleepQuality
StressLevel
PersonalData
Address
Citizenship
Email
Gender
MedicalHistory
SSN
DataProvider
Calendar
GPS
Kinect
Sensor
Affectiva
Beddit
Fitbit
Role
AboAcademy
Doctor
Nurse
Patient
TrustLevel
User
Object property hierarchy:
topObjectProperty
hasActiveRole
hasCredential
hasData
hasAddress
hasCitizenship
hasEmail
hasGender
hasMedicalHistory
hasSSN
hasOwner
hasPermission
hasModifyPermissionOfCredential
roleHasDeletePermissionOverData
roleHasReadPermissionOverData
roleHasUpdatePermissionOverData
roleHasWritePermissionOverData
userHasDeletePermissionOverData
userHasReadPermissionOverData
userHasUpdatePermissionOverData
userHasWritePermissionOverData
hasProhibition
roleHasDeleteProhibitionOverData
roleHasReadProhibitionOverData
roleHasUpdateProhibitionOverData
roleHasWriteProhibitionOverData
userHasDeleteProhibitionOverData
userHasReadProhibitionOverData
userHasUpdateProhibitionOverData
userHasWriteProhibitionOverData
hasProvenance
hasRole
hasTrustLevel
IsFamilyOf
ProvidesData
Data property hierarchy: hasAr
topDataProperty
hasAnonimizationID
hasDescription
hasTimestamp
hasValue
heartrate
movements
respirations
Individuals:
AAEmployee
AAStudent
AddressCoralie
AddressShohreh
AffectivaNatalia
AffectivaShohreh
BedditNatalia
BedditShohreh
BloodPressureShohreh
CalendarNatalia
CalendarShohreh
Coralie
DoctorAtRehabilitationWard
DoctorAtTYKS
EmailNatalia
EmailShohreh
Female
FitbitNatalia
FitbitShohreh
GPSNatalia
GPSShohreh
HeartRateShohreh
High
KinectNatalia
KinectShohreh
LocationCoralie
LocationNatalia1
LocationNatalia2
LocationNatalia3
LocationShohreh
Low
Male
Medium
Natalia
NurseAtTYKS
Piezoelectric
RehabilitationPatient
SelfConciousPatient
Shohreh
SSNCoralie
SSNNatalia
SSNShohreh
StressLevelCoralie
StressLevelNatalia
StressPatient

Avg exec. time for access control requests to the semantic information broker (M3 SIB)



Smart Space Application Protocol (SSAP) operations:

- Read
- Write
- Delete
- Update a triple

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Conclusion

We proposed

- Flexible security framework
  - fine and coarse grained information level
  - Smart Space security and privacy ontology available: https://github.com/NataliaDiaz/AccessControlOntology
- Access control scheme for Smart-M3 based spaces
  - http://sourceforge.net/projects/smart-m3/

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Future Work

- Security alert implementation with M3 pub/sub mechanism,
- Large scale deployment
- Micro-managing of personal data
- Data as a currency
- Integration into wearable camera & **Egoshots** dataset https://github.com/NataliaDiaz/Egoshots

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Thank you for your attention!

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