Towards Modeling and Evaluating SPM for XML Access Control

IL-GON KIM

Korea Information Security Agency

Overview

- Motivation
- Challenging Issues
- XML Access Control Model
- Formal Security Policy Model(SPM)
  - Schema, Query, and TSP using Xpath expression
  - Formal modeling of SPM using Process Algebra
- Verification Method
- Demonstration
- Conclusion

Motivation(1/2)

- Sensitive data (e.g., patient records) are increasingly becoming available in Web service paradigm and it has led to strong interest in access control to XML data.

- Access control policies for XML documents generally use path expressions such as XPath language to specify an authorized view to objects

Motivation(2/2)

- Formal Methods is required to get high assurance levels over EAL5 in Common Criteria.

- In CC v3.1, EAL 6 requires "*Formal TOE security policy model*".

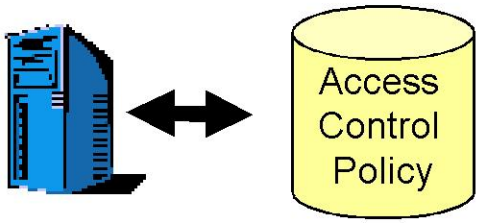
- ADV_SPM.1

  "*The model shall be in a **formal** style, supported by explanatory text as required, and identify the security policies of the TSF that are modelled.*
  (ADV_SPM.1.1C)

Challenging Issues

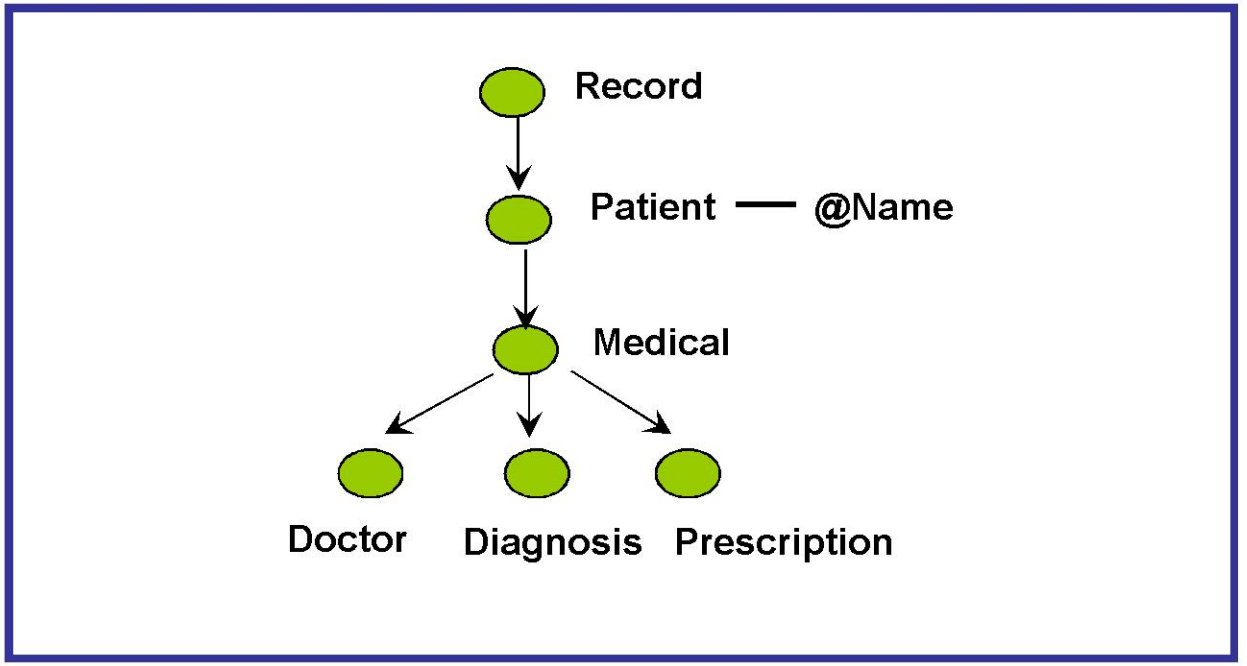
- Formal modeling and verification of SPM for XML documents are non-trivial topic because of it own challenging issues:
  - the hierarchical nature in XML documents
  - the policy specification using XPath query expression which specifies the tree path
  - the TSPs which do not need to define the policy for all the nodes in XML documents; In file systems like UNIX, the TSPs are defined for every elements

XML Access Control(1/3)

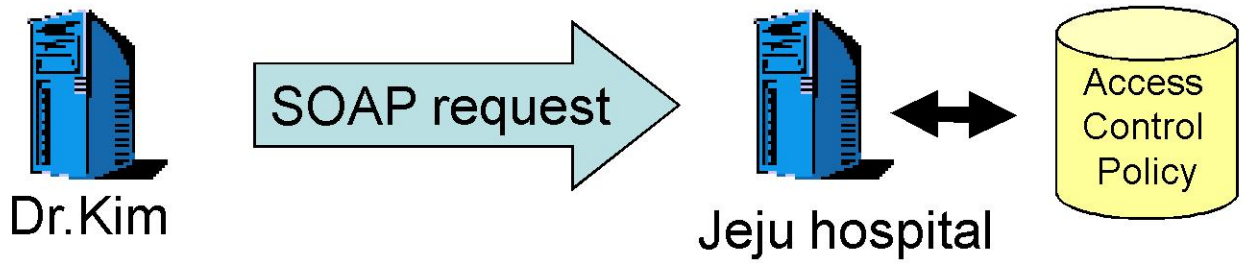


Jeju hospital

Tree Structure for Patient Records

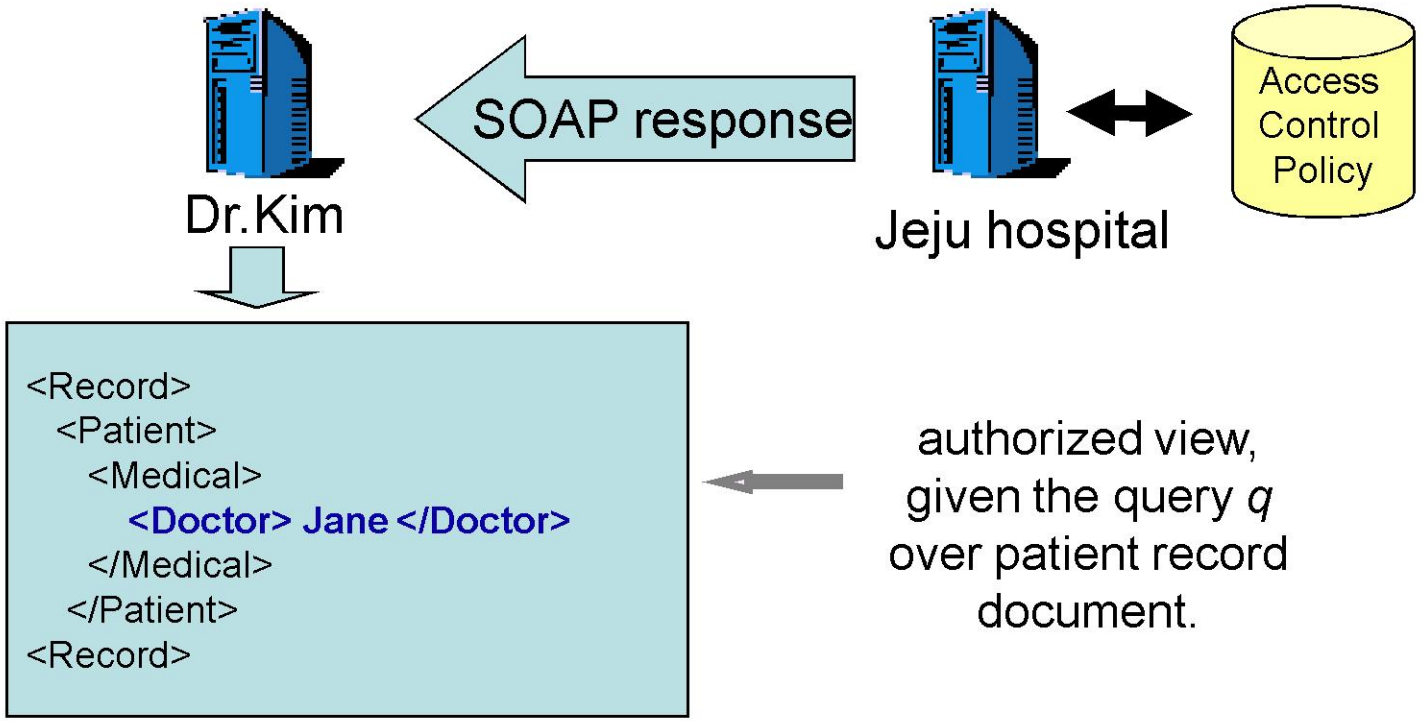


XML Access Control(2/3)



***q*=/Record/Patient[@Name=David]/Medical/Doctor/**

XML Access Control(3/3)



The ***authorized view*** is the restricted view of the XML document, which consists of the information that users are authorized to access after enforcement of the access control policies.

XPath language

- XPath is a XML path expression in order to express :

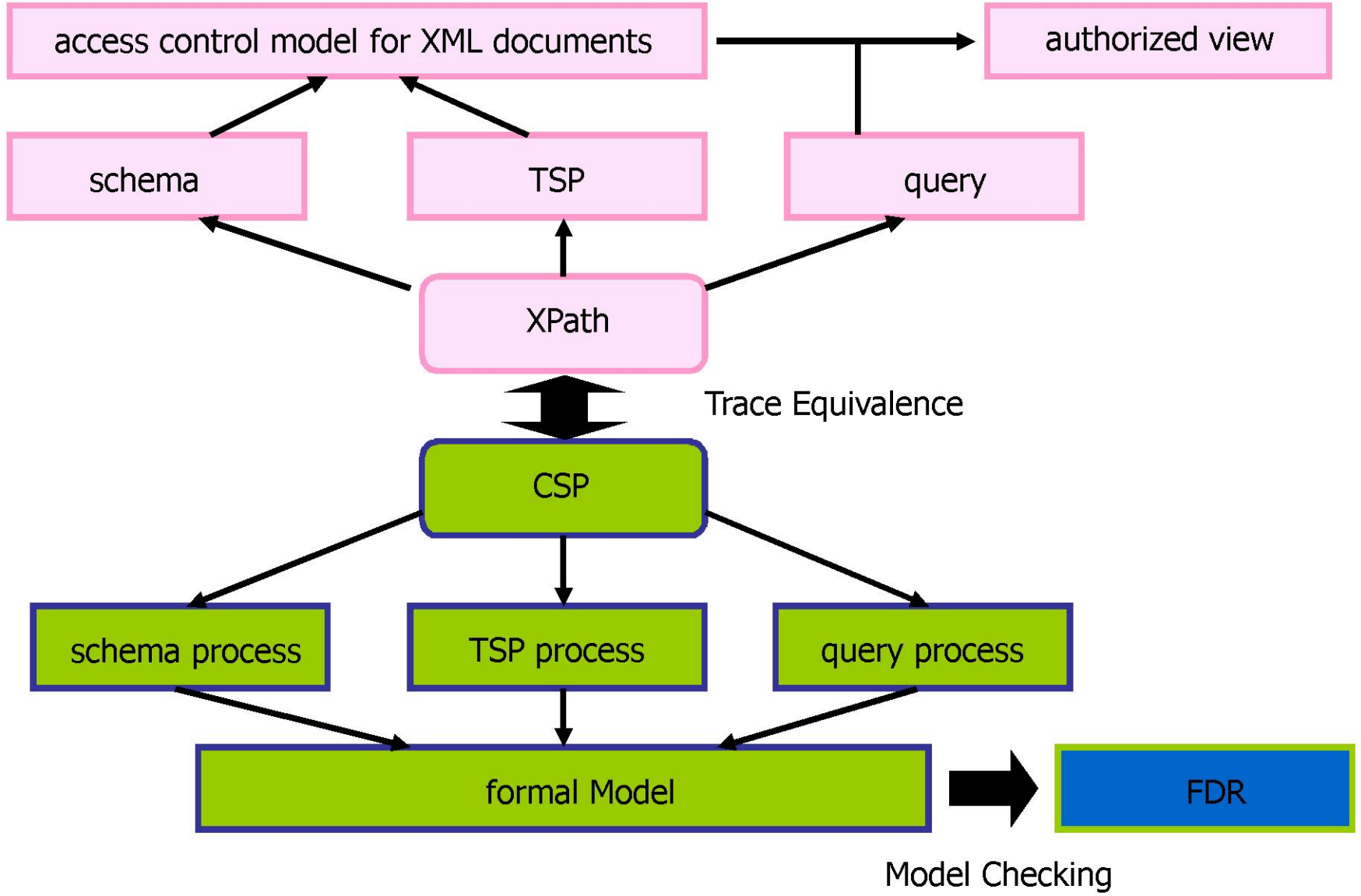
1) queries over documents, and

ex) q = /Record/Patient[@Name=David]/Medical

2) access control rules which users are allowed or denied to access specified objects.

ex) rule1 = <Dr. Kim, /Record/Patient[@Name=David]Medical/, read, +>

Formal Model for SPM (1/2)



Formal Model for SPM (2/2)

- First, translate query, schema, and TSPs into automata model.
- Second, describe them formal model using process algebra language, CSP(Communicating Sequential Processes).
- Third, use FDR model checking tool.

CSP (Communicating Sequential Processes)

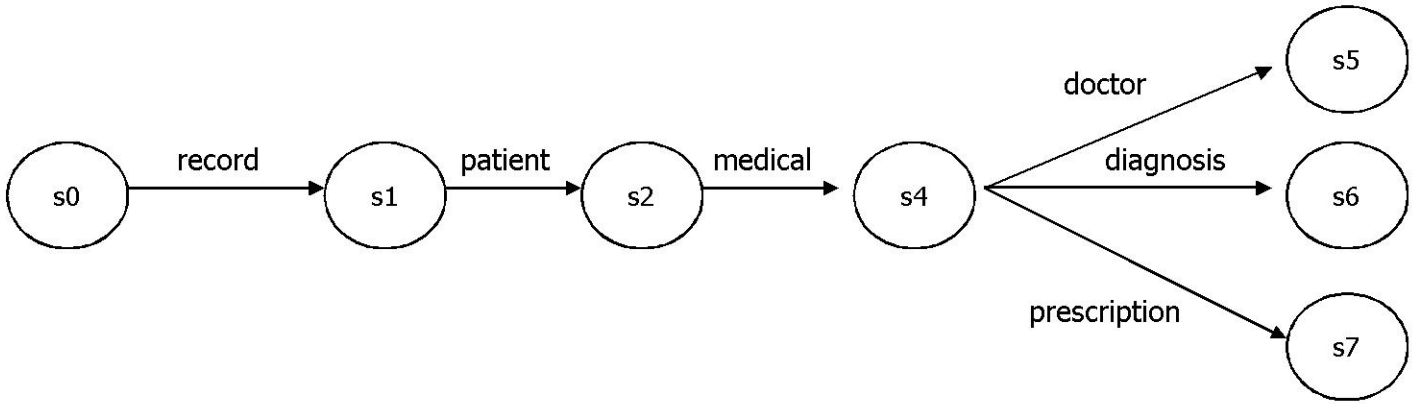
- The basic elements of CSP processes are action $a \in \Sigma$ (set of actions) and they are generated by the following syntax:

P::= STOP | a → P | P [] P | P |[A]| P | P ||| P

- STOP is deadlock termination process.
- Action prefix a → P behaves like P when a is performed.
- P [] Q denotes external choice.
- P[|A|] Q is parallel composition in which P and Q must synchronize over action in A.
- P ||| Q denotes an interleaving of two processes, where each process executes entirely independently of the other until termination.

Automata M^q for query q

q=/Record/Patient[@Name=David]/Medical/*



Modelling M^q in CSP

Q = record → patient → medical →
(doctor → STOP [ ]
diagnosis → STOP [ ]
prescription → STOP)

Modeling TSP in CSP

- Rule1=<Dr.Kim, read, /Record/Patient/Medical/Diagnosis>

ACR_1 = record → patient → medical →
diagnosis → STOP

CSP Model for XML Access Control

- Access control model AC can be described in CSP as below:
  - AC = S|[A]| TSP
  - TSP = (ACR_1 ||| ACR_2)

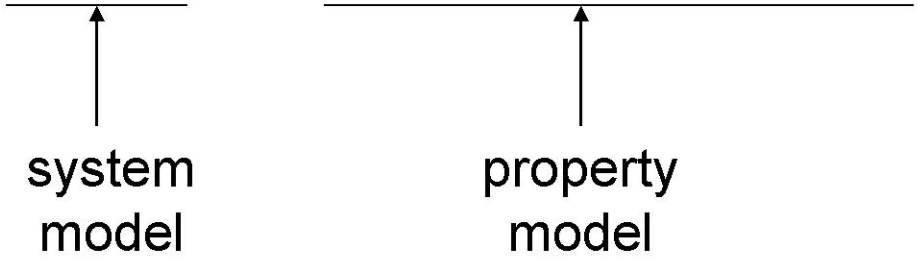
, where A is the event of all processes.

- The AV process for the authorized view can be obtained in CSP as below:
  - AV = AC [|A|] Q

Verification Method(1/2)

- The query q is always-granted if every path accepted by the query automata M^q is accepted by both the schema automata M^s and access control policy automata M^{TSP}:

$$L(M^q) \subseteq L(M^s) \cap L(M^{TSP})$$



- assert S ||[A]|| TSF $\sqsubseteq_T$ Q

Verification Methods(2/2)

q = Record/Patient/Medical/*

rule 1 = /Record/Patient/Medical/Diagnosis
rule 2 = /Record/Patient/Medical/Prescription

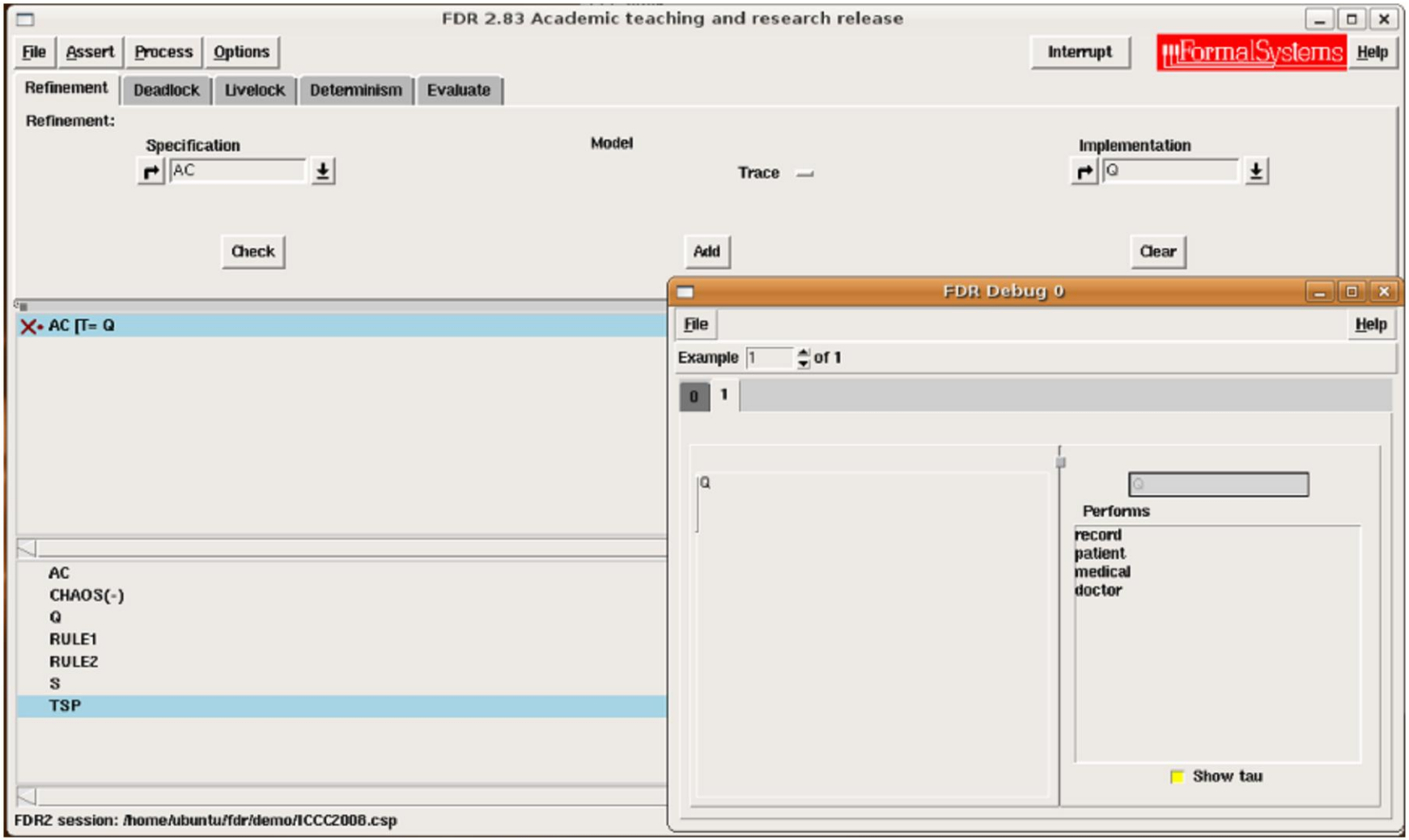
Property: Can Dr.Kim access the sub-nodes under Medical node ?

$L(M^q) \subseteq L(M^s) \cap (L(M^{rule1}) \cup L(M^{rule2}))$

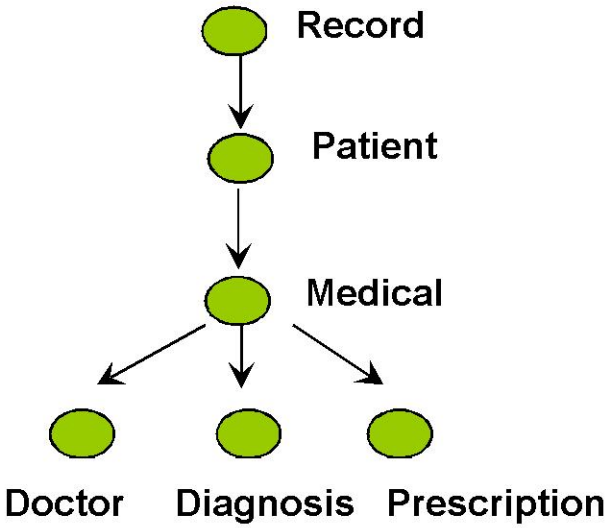
we can find the counterexample in CSP events:
<record, patient, medical, doctor>

This result means that the access to the node **Doctor** is not permitted for Dr. Kim against the query *q*.

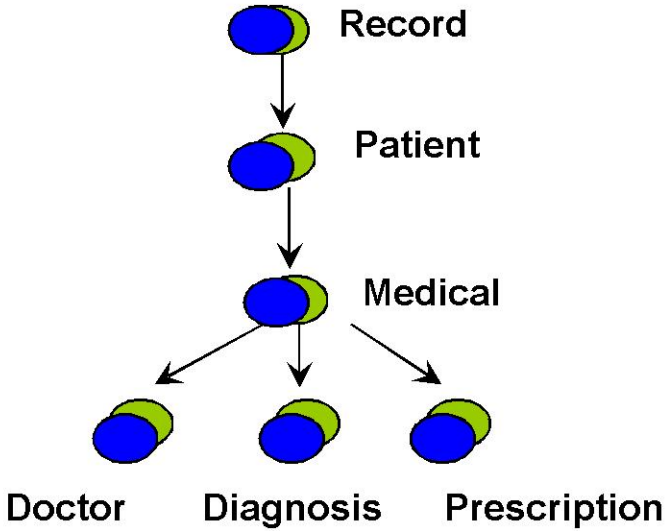
Verification Result



Schema S



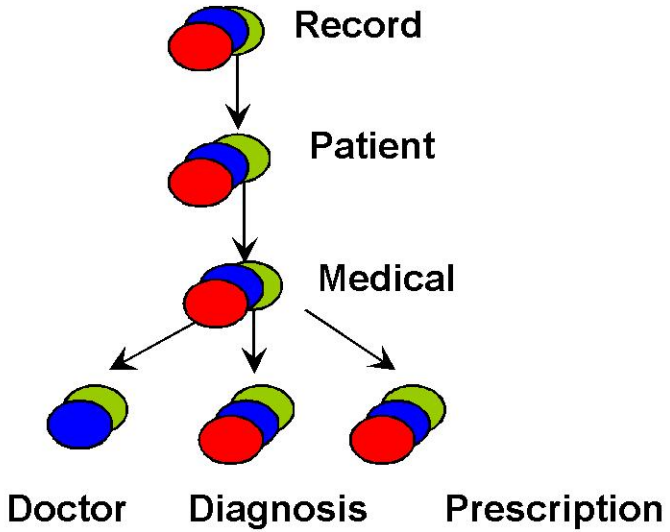
Query q and access control rules



q=/Record/Patient/Medical/*

Rule1=<Dr.Kim, /Record/Patient/Medical/Diagnosis, read, +>
Rule2=<Dr.Kim, /Record/Patient/Medical/Prescription, read, +>

Authorized View d' of XML Document (1/2)

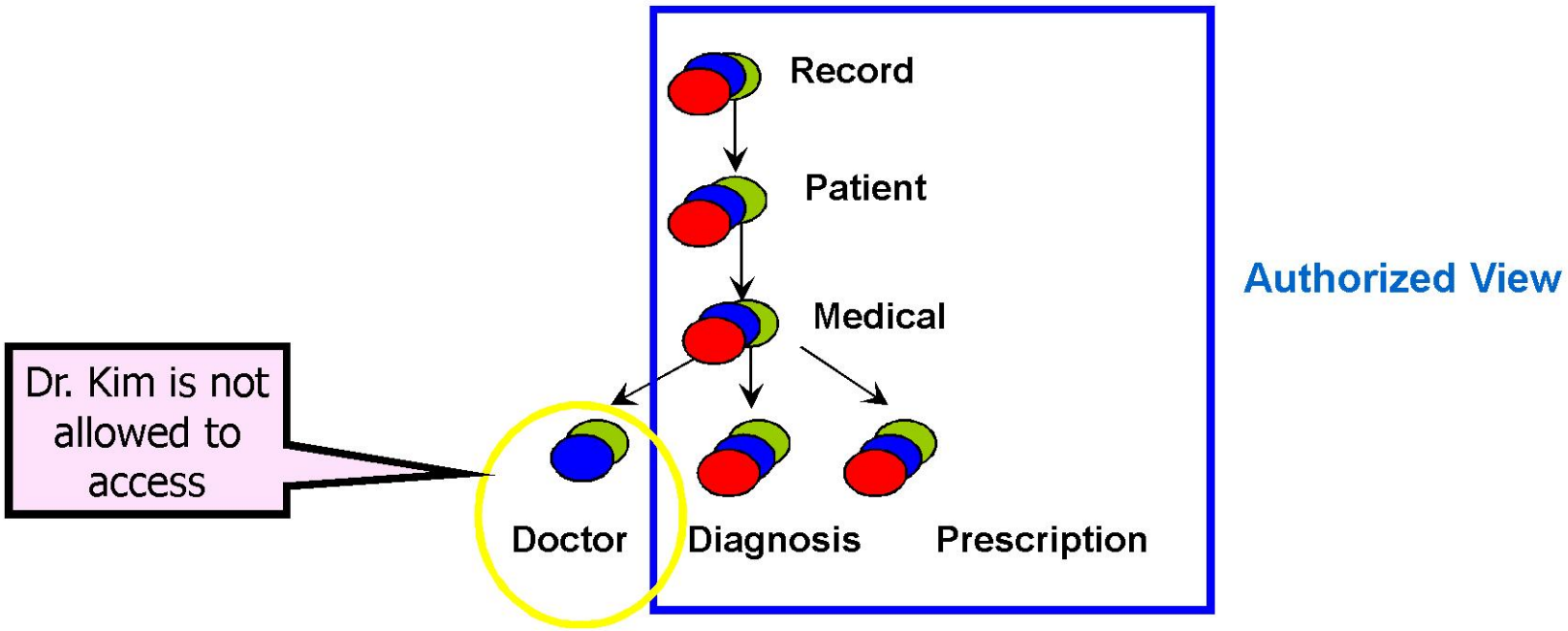


q=/Record/Patient/Medical/*

Rule1=<Dr.Kim, /Record/Patient/Medical/Diagnosis, read, +>
Rule2=<Dr.Kim, read, /Record/Patient/Medical/Prescription, read, +>

d' = schema s ∩ query q ∩ *rule1*

Authorized View d' of XML Document (2/2)



q=/Record/Patient/Medical/*

Rule1=<Dr.Kim, /Record/Patient/Medical/Diagnosis, read, +>
Rule2=<Dr.Kim, /Record/Patient/Medical/Prescription, read, +>

d' = /Record/Patient/Medical/(Diagnosis ∪ Prescription)

Conclusion

- We have presented how to specify schema, query, access control policies consisting of a SPM by interpreting XPath expression.
- We have shown how to analyze the SPM for XML documents as tree data structure in CSP language.
- Our static verification technique can not only determine whether the requested query is permitted by the schema-level access control policy or not, but also show a hierarchical path if access to data is allowed or not.


Q & A