Access Control Policy Tool (ACPT)

ACPT:
Access Control Policy Tool

Access Control Policy

Presently Policy authoring are hand crafted by administrators, and difficult to check for correctness, we need tool for:

- Composing policy by structure framework
- Detecting conflicts in policy rules
- Efficient testing of implementation
- Policy code generation

Outline

Access Control Policy Tool (ACPT) Overview

Approaches

- Model specification and composition
- Property verification
- Policy testing
- XACML generation

Related work

Future work

ACPT Overview - Functions

Composition

Allows specification of policy combinations, rules and properties through model and rule templates.

Verification

Allows testing and verification of policies against specified properties and reports problems that may lead to security holes.

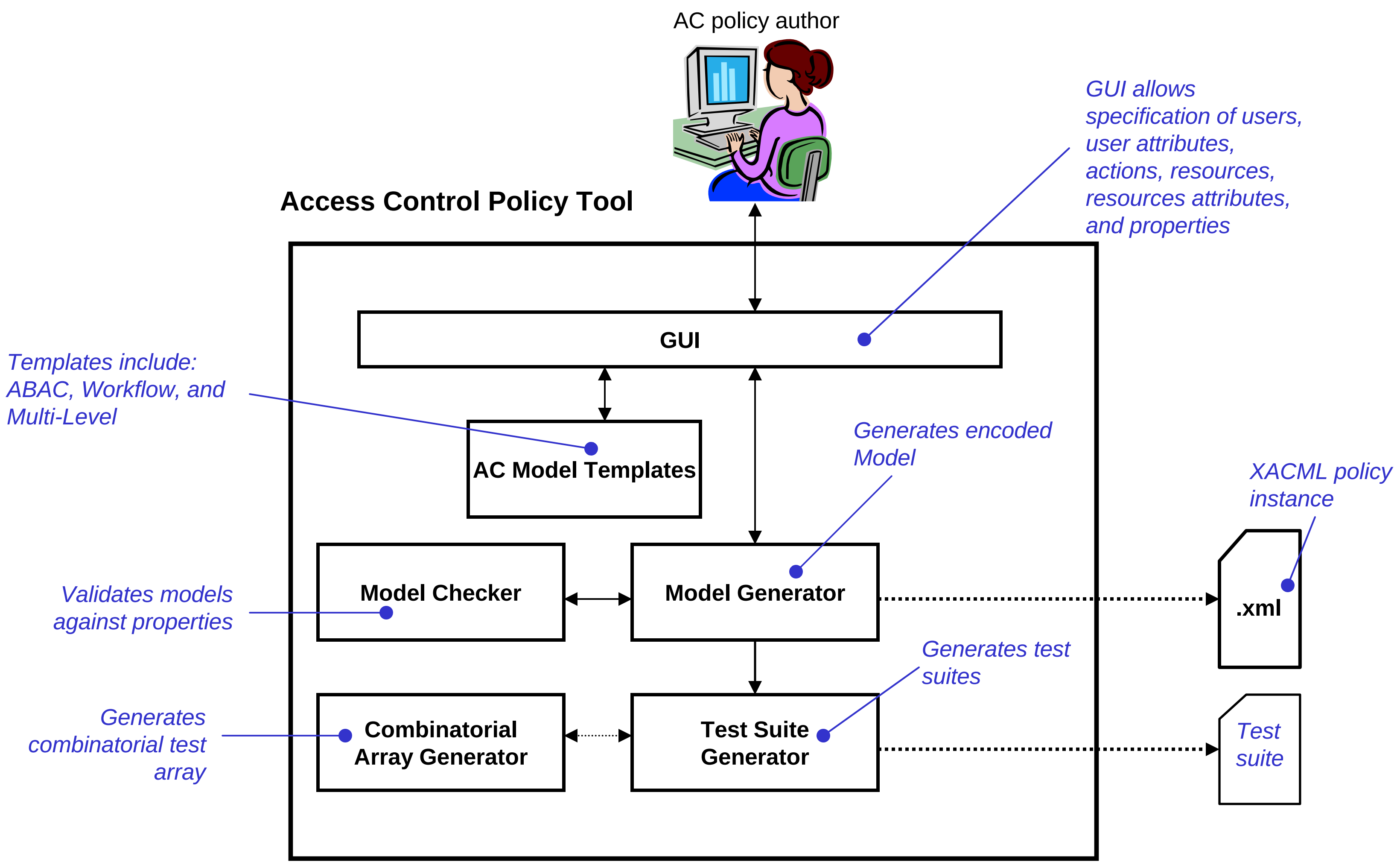
Testing

Generates efficient test suites (by applying NIST's combinatorial testing technology) for testing of access control implementation, test suites can be applied to any access control implementation.

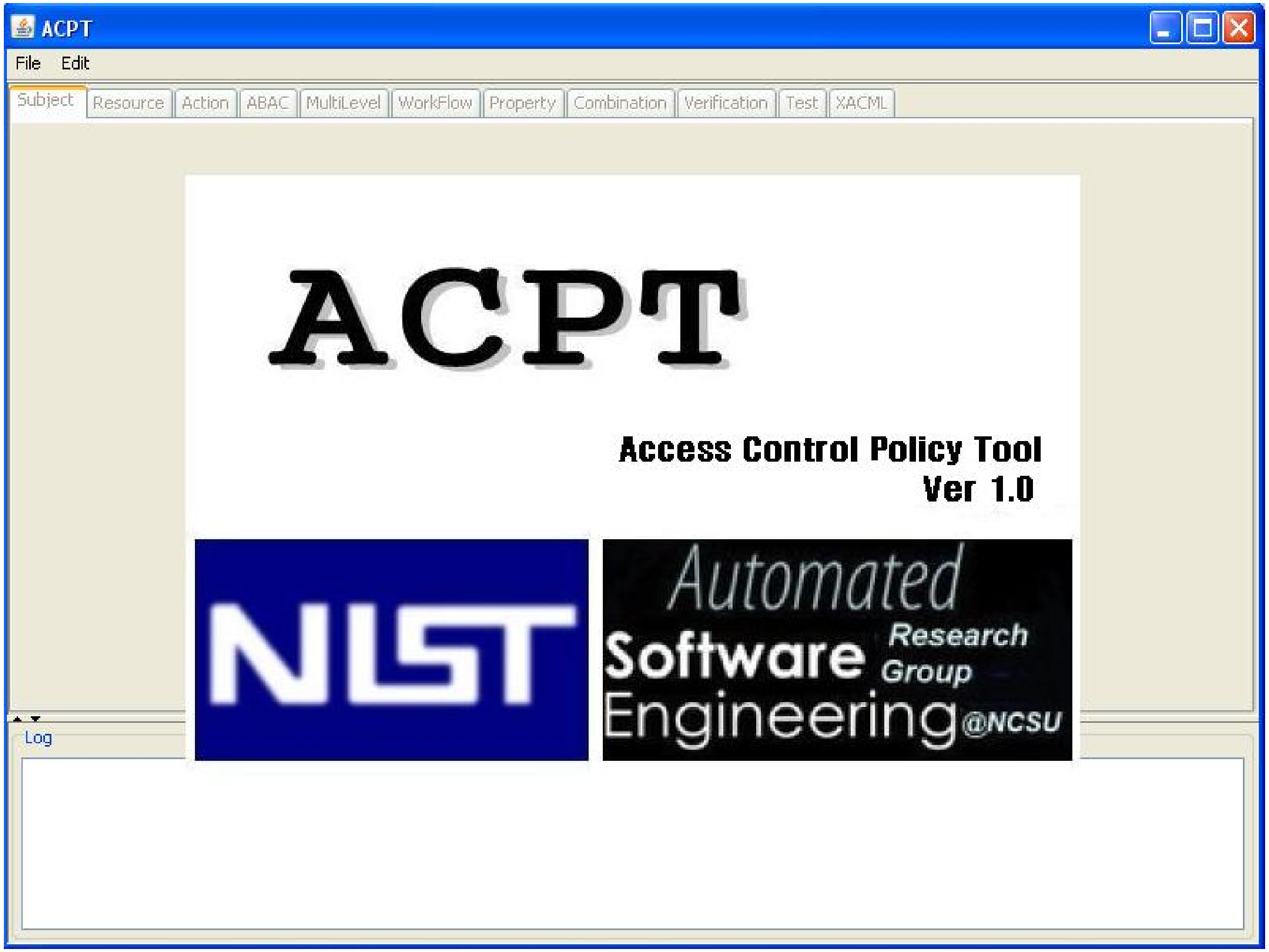
Policy

XACML policy generation.

ACPT Overview - Architecture


AC policy author
Access Control Policy Tool
GUI allows specification of users, user attributes, actions, resources, resources attributes, and properties
GUI
Templates include: ABAC, Workflow, and Multi-Level
AC Model Templates
Generates encoded Model
XACML policy instance
Model Checker
Model Generator
.xml
Validates models against properties
Generates test suites
Generates combinatorial test array
Combinatorial Array Generator
Test Suite Generator
Test suite

ACPT Overview

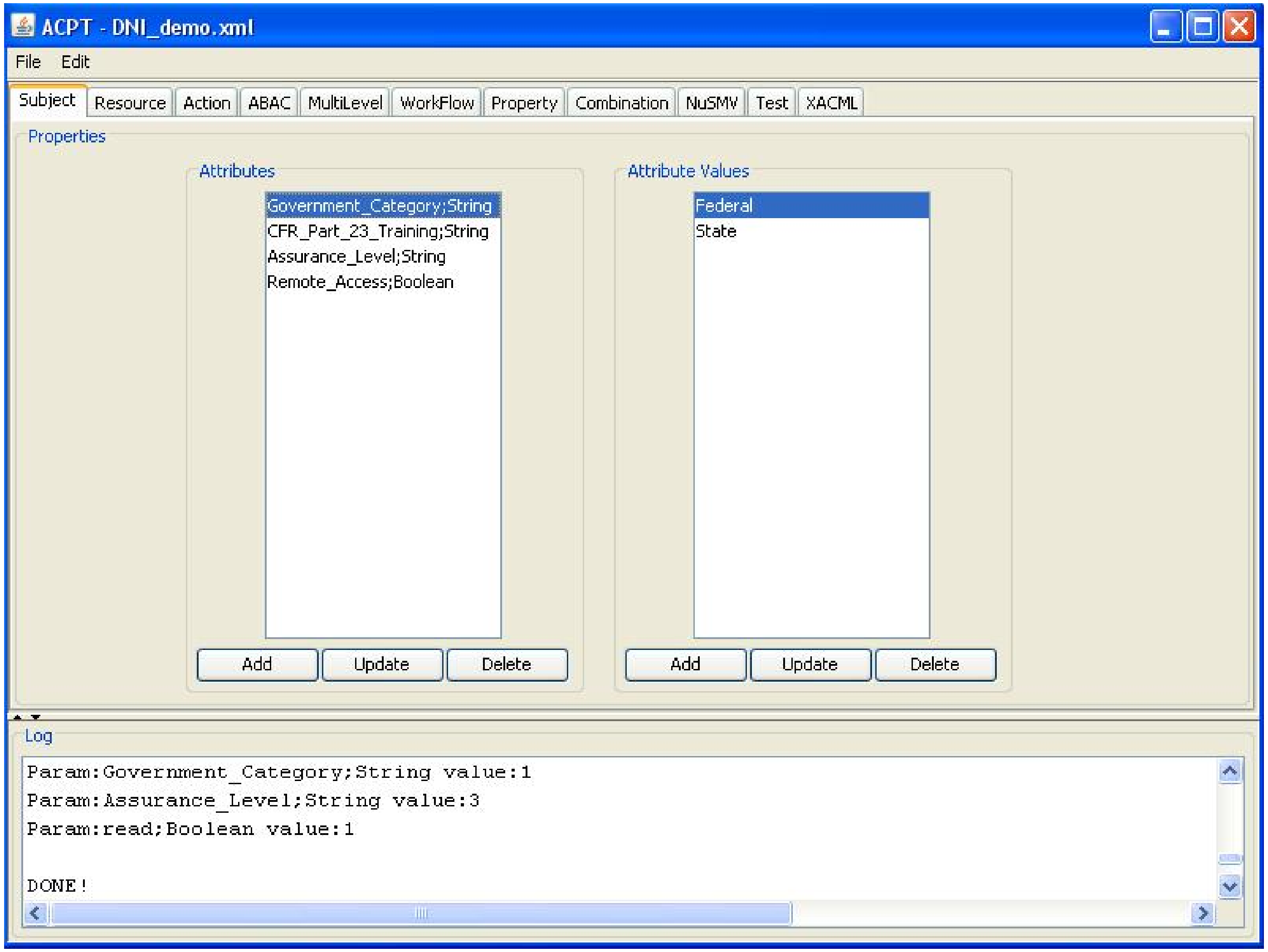


Approaches: AC Model Specification and Composition

Allow to conveniently specify mandatory AC models (as well as AC rules) through pre-defined model templates

- Allow to create various models by specifying attribute values e.g., role subjects, resources, and actions for RBAC, user and resources ranks for MLS.
- Combine different AC models or rules into a composed one e.g., combine RBAC with multi-level models.
- allow to configure model priority for combining models or rules.

Approaches: AC Model Specification and Composition - Example



Attributes	Attribute Values
Government_Category;String	Federal
CFR_Part_23_Training;String	State
Assurance_Level;String	
Remote_Access;Boolean	

```
Param:Government_Category;String value:1
Param:Assurance_Level;String value:3
Param:read;Boolean value:1

DONE!
```

Approaches: Property Verification

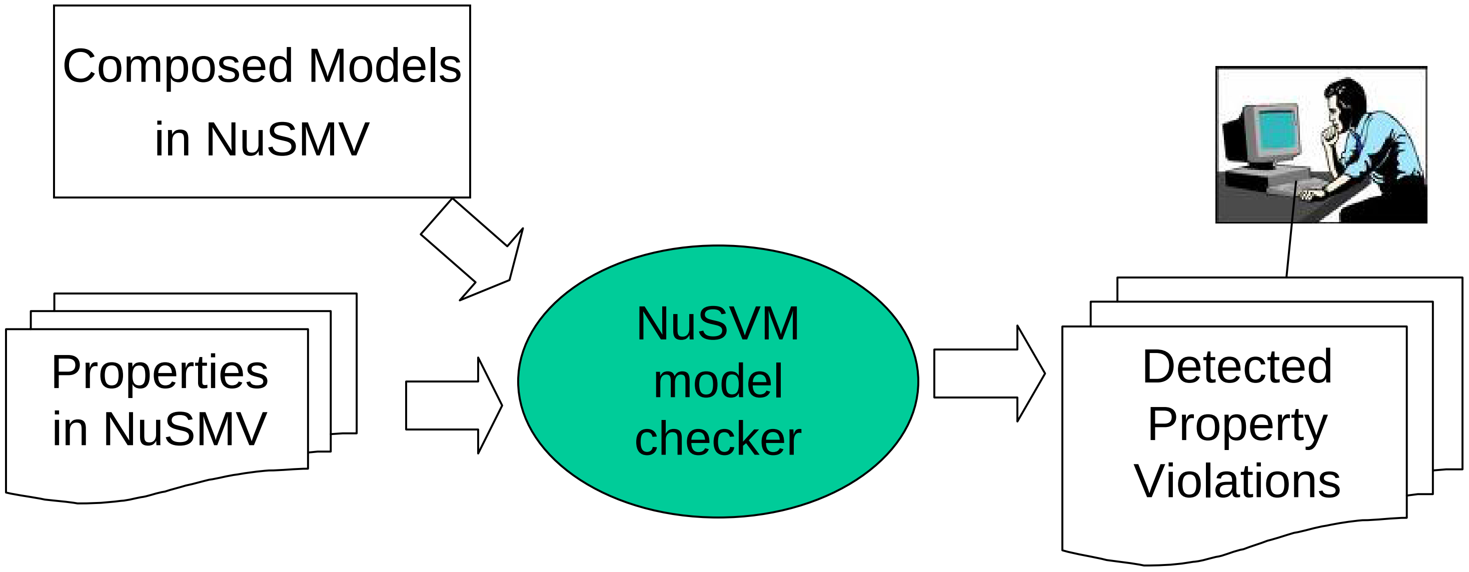
Conflicts among policy entities and their complexity may leak unauthorized or prohibit authorized access privileges.

• Convert composed models and user-specified properties to input models and properties for a model checker (e.g., NuSMV).

• Verify models against specified properties, and report detected property violations.

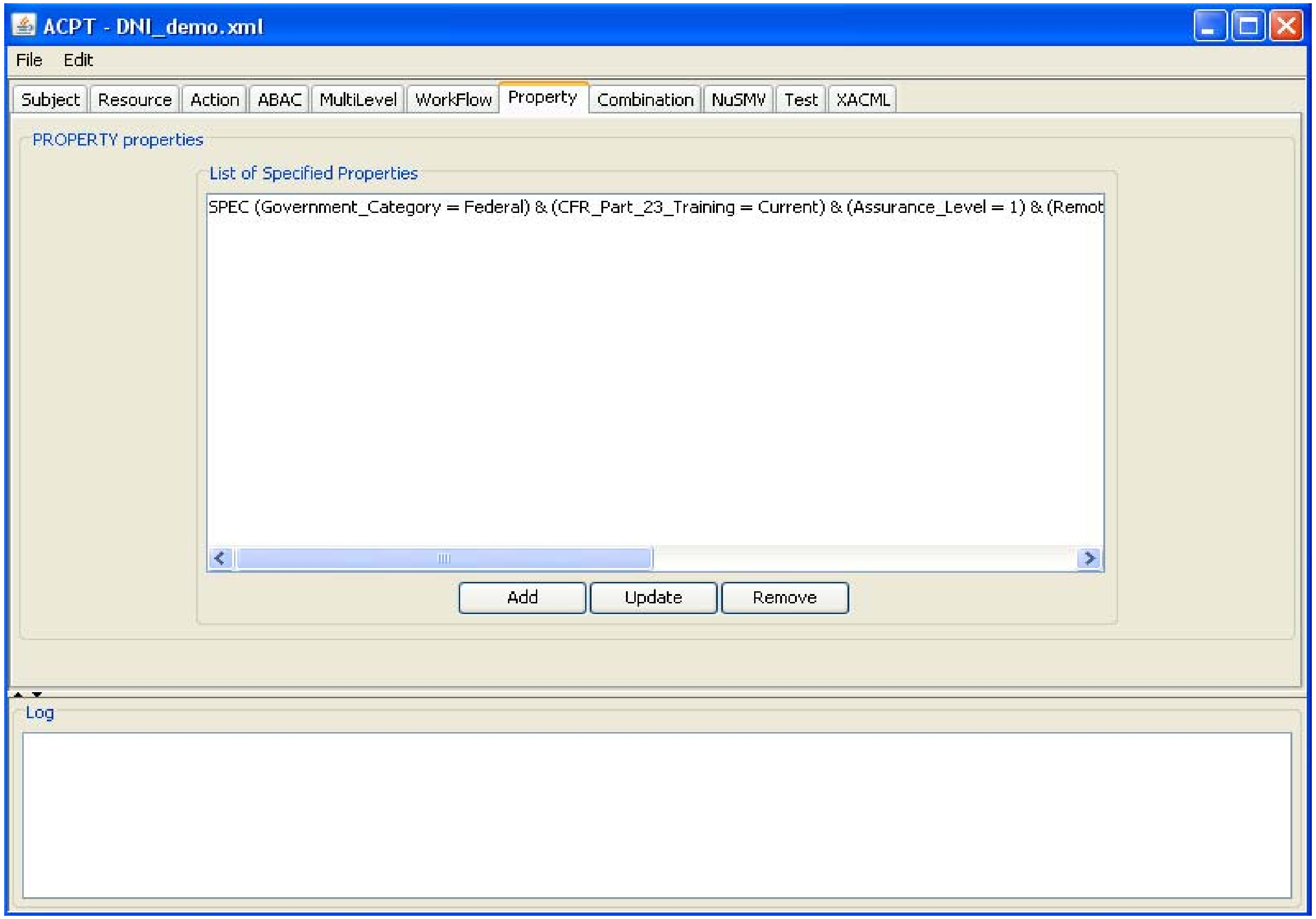
Approaches: Property Verification cont.

ACPT uses the NuSMV model checker, a well-structured, flexible, and efficient tool (supporting CTL and LTL model checking)



Approaches: Property Verification - Example

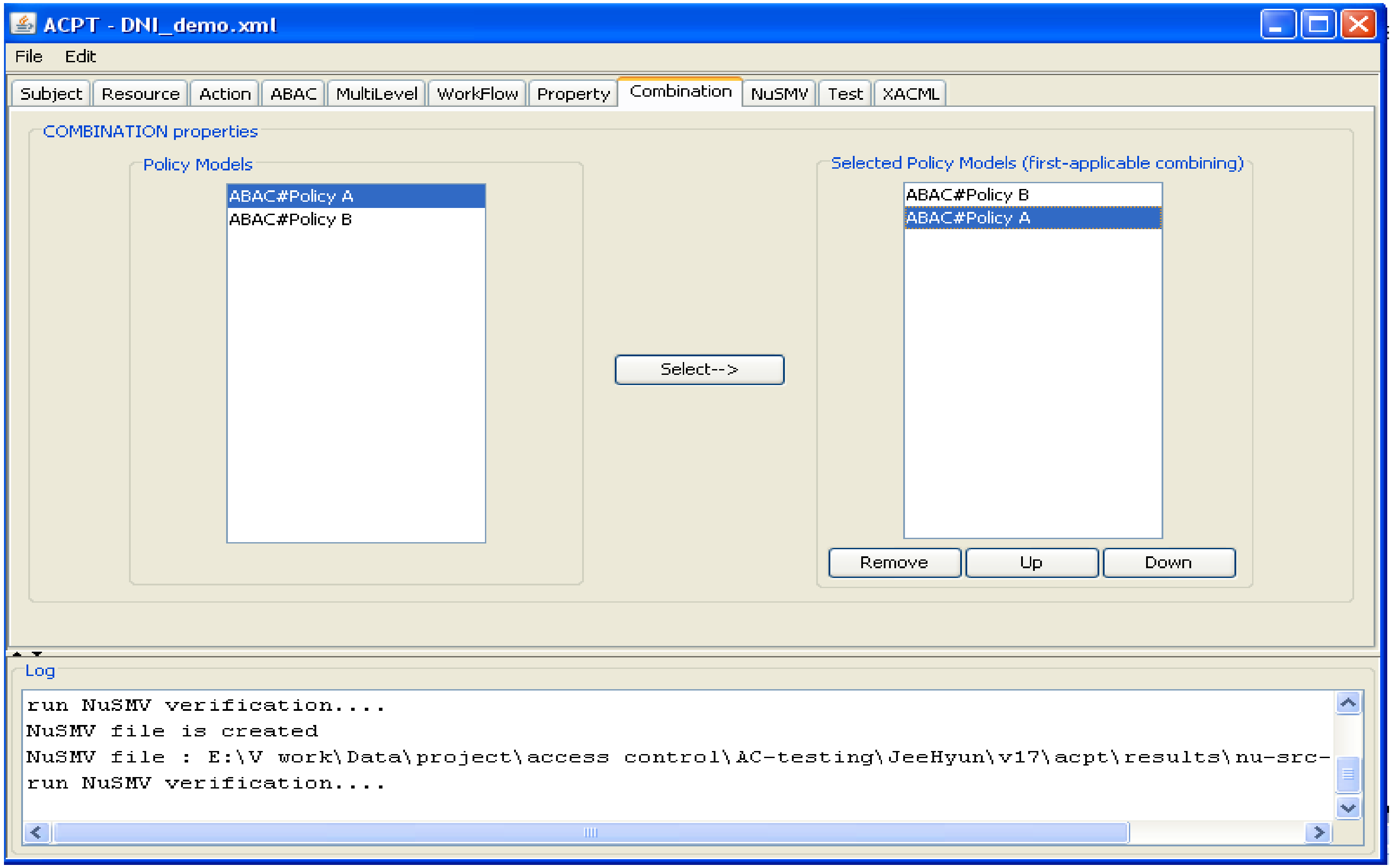
Property specification in ACPT



SPEC (Government_Category = Federal) & (CFR_Part_23_Training = Current) & (Assurance_Level = 1) & (Remot

Approaches: Property Verification – Example cont.

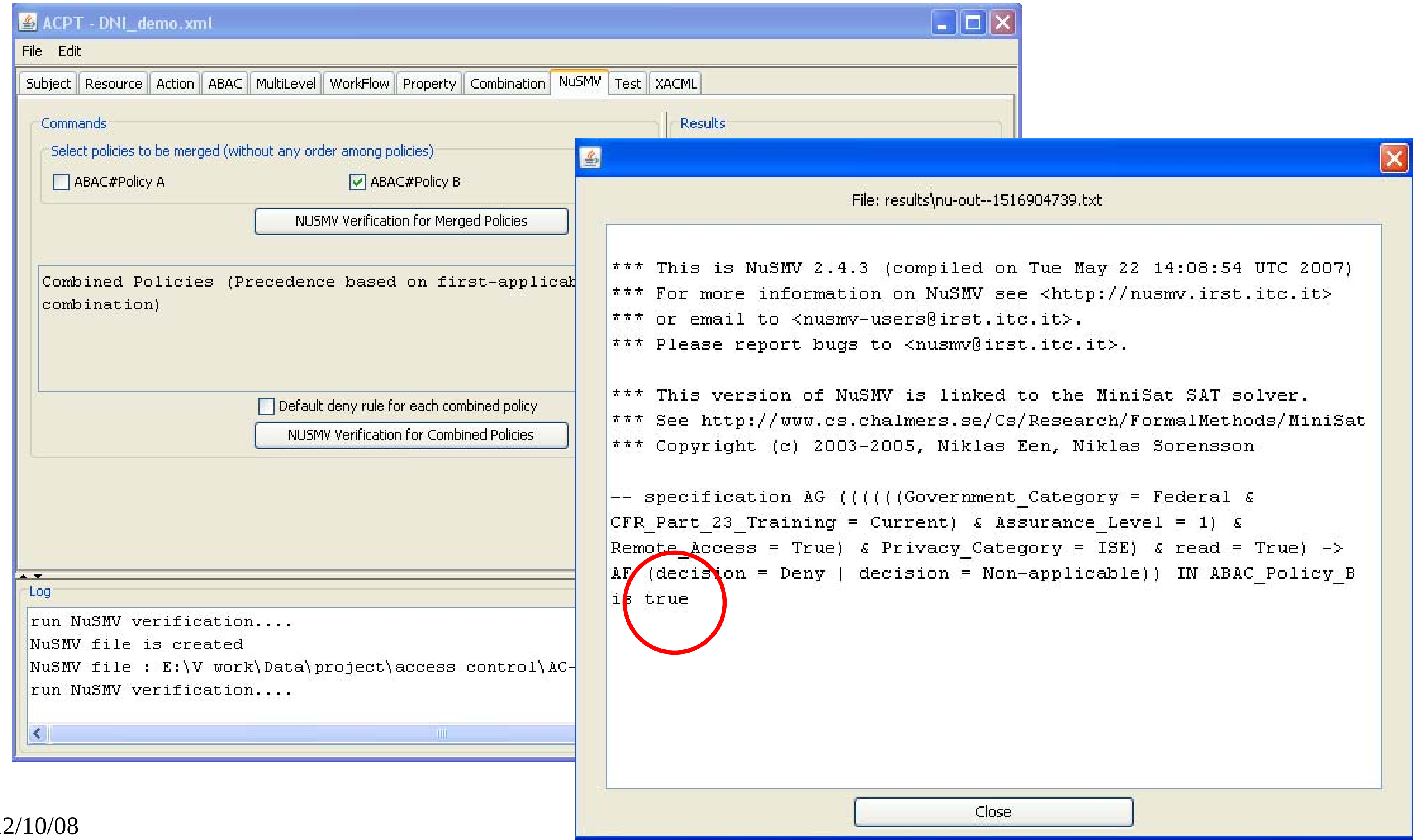
Test the property against Policy A **combined** with Policy B. Combined polices has the priorities of the combined rules. This slide shows the combination of policies, where Policy B has higher priority than policy A



```
run NuSMV verification....
NuSMV file is created
NuSMV file : E:\V work\Data\project\access control\AC-testing\JeeHyun\v17\acpt\results\nu-src-
run NuSMV verification....
```

Approaches: Property Verification – Example cont.

Test the property against Policy B, the result return *true*.


ACPT - DNI_demo.xml
File Edit
Subject Resource Action ABAC MultiLevel WorkFlow Property Combination NuSMV Test XACML
Commands
Select policies to be merged (without any order among policies)
ABAC#Policy A
[✓ ABAC#Policy B]
NUSMV Verification for Merged Policies
Default deny rule for each combined policy
NUSMV Verification for Combined Policies
Results
Log
Close

```
Combined Policies (Precedence based on first-applicab
combination)
```

```
run NuSMV verification....
NuSMV file is created
NuSMV file : E:\V work\Data\project\access control\AC-
run NuSMV verification....
```

File: results\nu-out--1516904739.txt

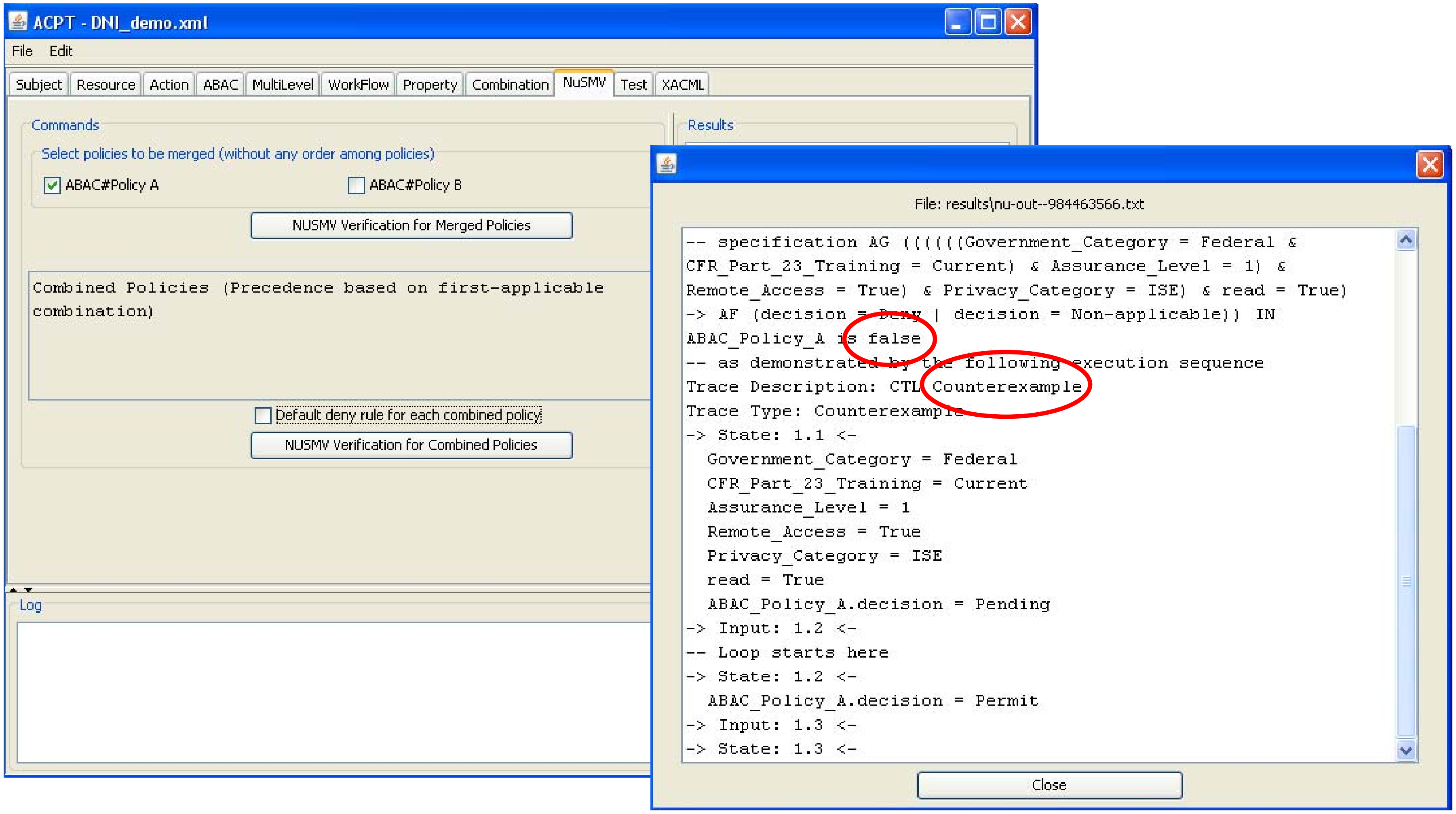
```
*** This is NuSMV 2.4.3 (compiled on Tue May 22 14:08:54 UTC 2007)
*** For more information on NuSMV see <http://nusmv.irst.itc.it>
*** or email to <nusmv-users@irst.itc.it>.
*** Please report bugs to <nusmv@irst.itc.it>.

*** This version of NuSMV is linked to the MiniSat SAT solver.
*** See http://www.cs.chalmers.se/Cs/Research/FormalMethods/MiniSat
*** Copyright (c) 2003-2005, Niklas Een, Niklas Sorensson

-- specification AG ((((((Government_Category = Federal &
CFR_Part_23_Training = Current) & Assurance_Level = 1) &
Remote_Access = True) & Privacy_Category = ISE) & read = True) ->
AF (decision = Deny | decision = Non-applicable)) IN ABAC_Policy_B
is true
```

Approaches: Property Verification – Example cont.

Test the property against Policy A, the result return *false* with counterexample.

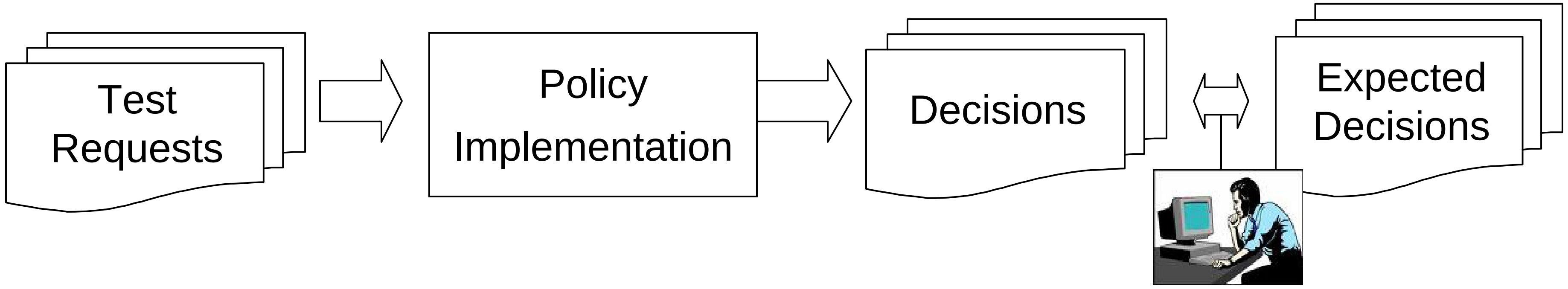

ACPT - DNI_demo.xml
File Edit
Subject Resource Action ABAC MultiLevel WorkFlow Property Combination NuSMV Test XACML
Commands
Select policies to be merged (without any order among policies)
ABAC#Policy A
ABAC#Policy B
NUSMV Verification for Merged Policies
Default deny rule for each combined policy
NUSMV Verification for Combined Policies
Log
Results
File: results\nu-out--984463566.txt
Close

[✓ ABAC#Policy A] ABAC#Policy B

```
Combined Policies (Precedence based on first-applicable
combination)
```

```
-- specification AG ((((((Government_Category = Federal &
CFR_Part_23_Training = Current) & Assurance_Level = 1) &
Remote_Access = True) & Privacy_Category = ISE) & read = True)
-> AF (decision = Deny | decision = Non-applicable)) IN
ABAC_Policy_A is false
-- as demonstrated by the following execution sequence
Trace Description: CTL Counterexample
Trace Type: Counterexample
-> State: 1.1 <-
  Government_Category = Federal
  CFR_Part_23_Training = Current
  Assurance_Level = 1
  Remote_Access = True
  Privacy_Category = ISE
  read = True
  ABAC_Policy_A.decision = Pending
-> Input: 1.2 <-
-- Loop starts here
-> State: 1.2 <-
  ABAC_Policy_A.decision = Permit
-> Input: 1.3 <-
-> State: 1.3 <-
```

Approaches: Policy Testing



Assure correct policy implementations by

- Test Generation: Generate *test requests.*
- Test Execution: Evaluate test requests (against policy implementations) and produce their decisions.
- Test-Result Evaluation: Check if the decisions are consistent with expected decisions (from properties or manual inspection, etc.).
  - If inconsistent, implementation faults are revealed.

Approaches: Policy Testing – Combinatorial Testing

Exhaustive testing is impractical (esp. for large number of AC entities).

Generating efficient and effective test suites (from AC models) using Combinatorial Array Generation Technology.

Generated test suites can be applied to any access control implementations in practice to find implementation faults

Approaches: Policy Testing - Combinatorial Test cont.

Collect domain variables in AC models and generate ***efficient*** test suite automatically to detect faults using NIST combinatorial testing tool (ACTS)

- inputs: a domain of variables
- outputs: t-way covering arrays as tests

For example, domain of variables:

2 subjects: Faculty and Student

2 actions: write and view

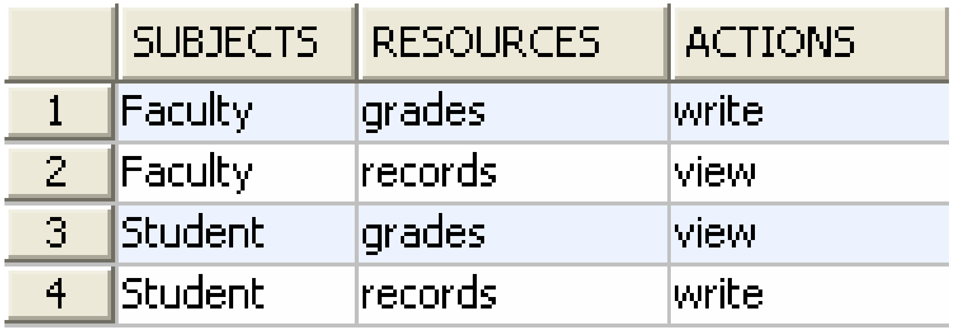
2 resources: grades and records

Given the domain, 4 and 8 tests are generated for 2-way and 3-way interactions, respectively

<Faculty, grades, write>, <Faculty, records, view >, …

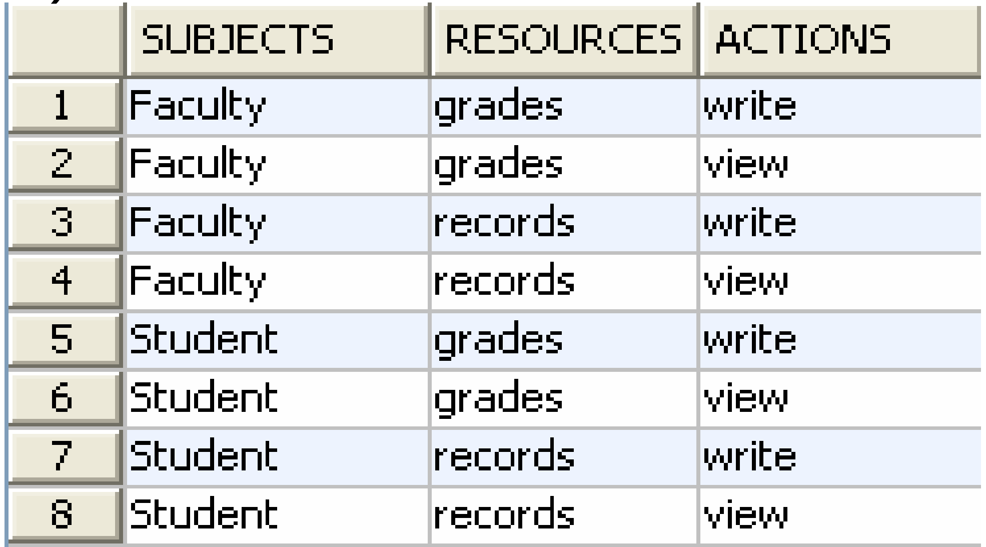
Approaches: Policy Testing - Combinatorial Test cont.

•Combinatorial tests based on 2-way interactions



	SUBJECTS	RESOURCES	ACTIONS
1	Faculty	grades	write
2	Faculty	records	view
3	Student	grades	view
4	Student	records	write

•Combinatorial tests based on 3-way interactions (being exhaustive tests)



	SUBJECTS	RESOURCES	ACTIONS
1	Faculty	grades	write
2	Faculty	grades	view
3	Faculty	records	write
4	Faculty	records	view
5	Student	grades	write
6	Student	grades	view
7	Student	records	write
8	Student	records	view

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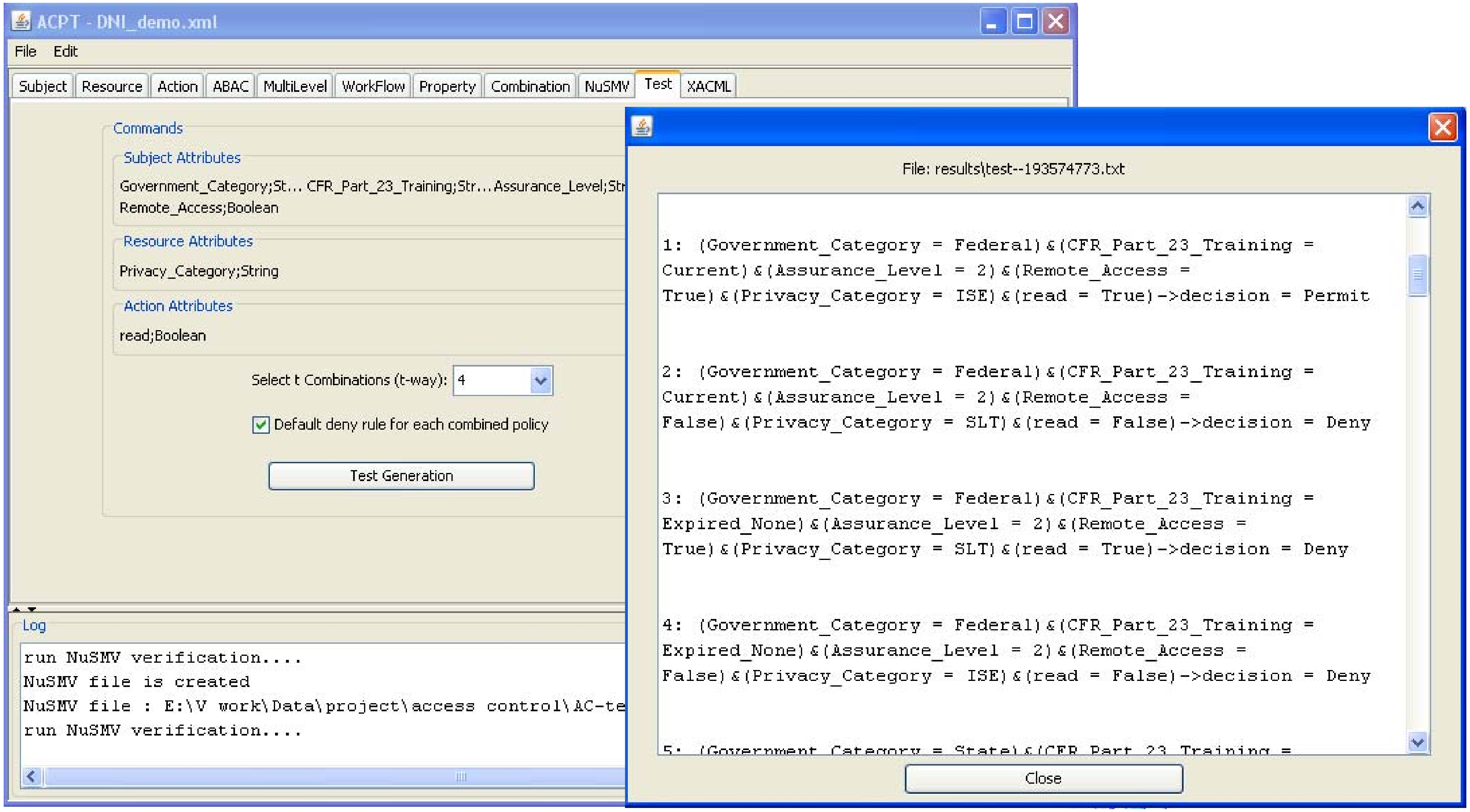
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

INFORMATION TECHNOLOGY LABORATORY

Approaches: Policy Testing – Example

Test cases generation:


ACPT - DNI_demo.xml
File Edit
Subject Resource Action ABAC MultiLevel WorkFlow Property Combination NuSMV Test XACML
Commands
Subject Attributes
Resource Attributes
Action Attributes
Test Generation
Log
File: results\test--193574773.txt
Close

Government_Category;St… CFR_Part_23_Training;Str… Assurance_Level;Str
Remote_Access;Boolean

Privacy_Category;String

read;Boolean

Select t Combinations (t-way): 4

[✓] Default deny rule for each combined policy

```
run NuSMV verification....
NuSMV file is created
NuSMV file : E:\V work\Data\project\access control\AC-te
run NuSMV verification....
```

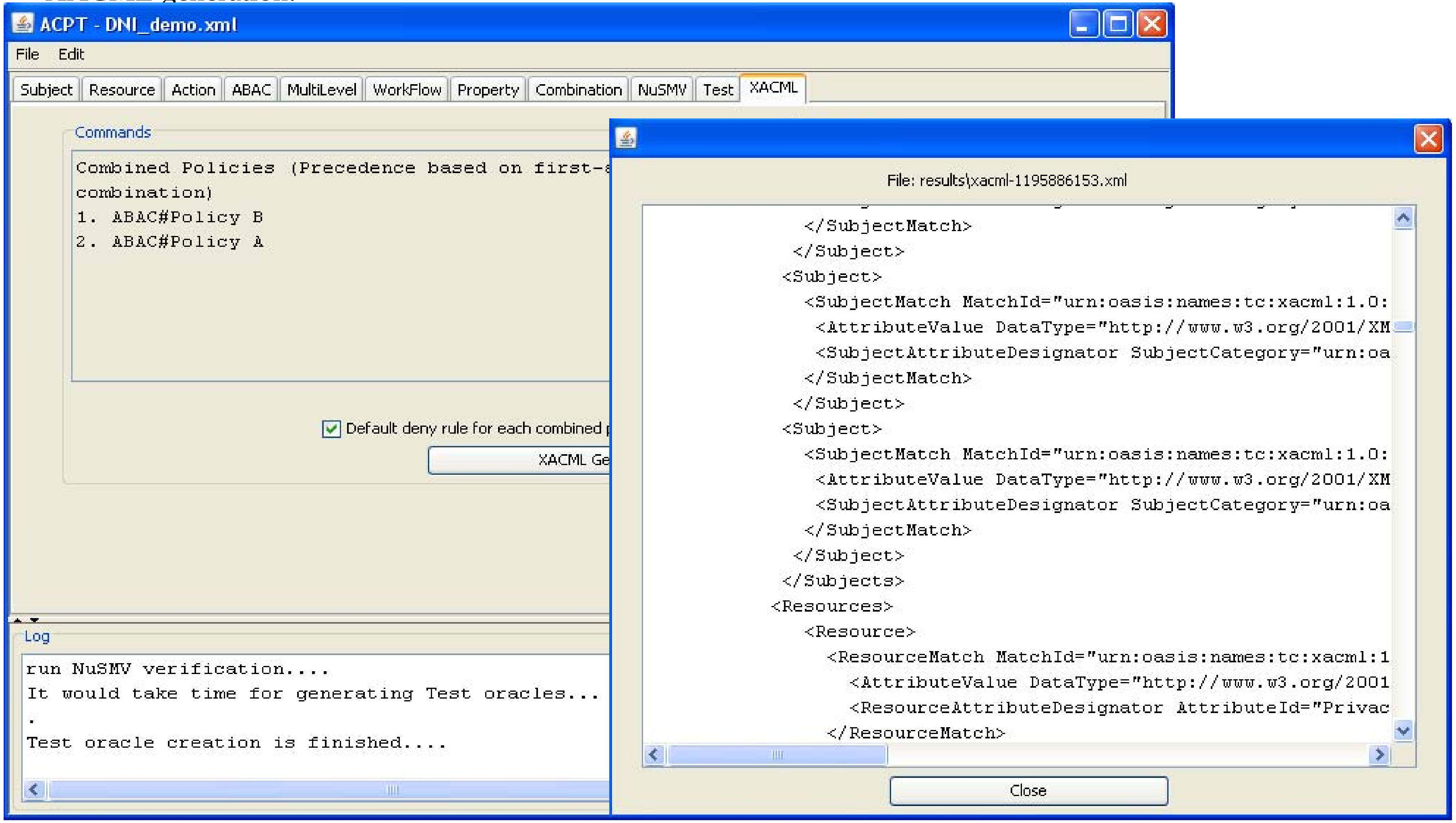
```
1:  (Government_Category = Federal)&(CFR_Part_23_Training =
Current)&(Assurance_Level = 2)&(Remote_Access =
True)&(Privacy_Category = ISE)&(read = True)->decision = Permit


2:  (Government_Category = Federal)&(CFR_Part_23_Training =
Current)&(Assurance_Level = 2)&(Remote_Access =
False)&(Privacy_Category = SLT)&(read = False)->decision = Deny


3:  (Government_Category = Federal)&(CFR_Part_23_Training =
Expired_None)&(Assurance_Level = 2)&(Remote_Access =
True)&(Privacy_Category = SLT)&(read = True)->decision = Deny


4:  (Government_Category = Federal)&(CFR_Part_23_Training =
Expired_None)&(Assurance_Level = 2)&(Remote_Access =
False)&(Privacy_Category = ISE)&(read = False)->decision = Deny


5:  (Government_Category = State)&(CFR_Part_23_Training =
```

Approaches: XACML Generation

Generate XACML policy based on the verified (combined or individual) models and rules.

Approaches: XACML Generation – Example

XACML generation:


ACPT - DNI_demo.xml
File Edit
Subject Resource Action ABAC MultiLevel WorkFlow Property Combination NuSMV Test XACML
Commands
Log
XACML Ge
File: results\xacml-1195886153.xml
Close

```
Combined Policies (Precedence based on first-
combination)
1. ABAC#Policy B
2. ABAC#Policy A
```

☑ Default deny rule for each combined p

```
run NuSMV verification....
It would take time for generating Test oracles...
.
Test oracle creation is finished....
```

```
              </SubjectMatch>
             </Subject>
            <Subject>
              <SubjectMatch MatchId="urn:oasis:names:tc:xacml:1.0:
               <AttributeValue DataType="http://www.w3.org/2001/XM
               <SubjectAttributeDesignator SubjectCategory="urn:oa
              </SubjectMatch>
             </Subject>
            <Subject>
              <SubjectMatch MatchId="urn:oasis:names:tc:xacml:1.0:
               <AttributeValue DataType="http://www.w3.org/2001/XM
               <SubjectAttributeDesignator SubjectCategory="urn:oa
              </SubjectMatch>
             </Subject>
            </Subjects>
           <Resources>
              <Resource>
                <ResourceMatch MatchId="urn:oasis:names:tc:xacml:1
                  <AttributeValue DataType="http://www.w3.org/2001
                  <ResourceAttributeDesignator AttributeId="Privac
                </ResourceMatch>
```

Approaches: XACML Generation – Example cont.

```
<PolicySet PolicySetId="n" PolicyCombiningAlgId="First-Applicable">
  <Target/>
  <Policy PolicyId="RBAC_school" RuleCombinationAlgId="First-Applicable">
    <Target/>
    <Rule RuleId="1" Effect="Deny">
      <Target>
        <Subjects><Subject>       Student   </Subject>
                  <Subject>       Secretary </Subject></Subjects>
        <Resources><Resource> Grades    </Resource></Resources>
        <Actions><Action>         Change    </Action></Actions>
      </Target>
    </Rule>
    <Rule RuleId="2" Effect="Permit">
      <Target>
        <Subjects><Subject>       Professor  </Subject>
                  <Subject>       Lecturer   </Subject>
                  <Subject>       Secretary  </Subject></Subjects>
        <Resources><Resource> Grades     </Resource>
                   <Resource> Records   </Resource></Resources>
        <Actions><Action>         Change     </Action>
                                               </Actions>
      </Target>
    </Rule>
  </Policy>
  <Policy PolicyId="ABAC_school" RuleCombinationAlgId="First-Applicable">
    <Target/>
    <Rule RuleId="3" Effect="Permit">
      <Target>
        <Subjects><Subject>       Jim    </Subject></Subjects>
        <Resources><Resource> Records  </Resource></Resources>
        <Actions><Action>         Change   </Action>
                 <Action>          Read     </Action></Actions>
      </Target>
    </Rule>
  </Policy>
</PolicySet>
```

Rule 1:
A student or secretary can not change grades.

Rule 2:
A professor, lecturer, or secretary can change grades or records.

RBAC_school policy

Rule 3:
Jim can change grades or records.

Policy rules

Related Work: Compare with Commercial AC Tools

A commercial AC policy management tool does not have all the following capabilities that NIST ACPT has:

- **AC model templates** for specifying models/polices: ABAC, Multi-Level, and Workflow.
- **Composition of multiple AC models** into a composed one, e.g., combine RBAC with MLS models.
- **AC property verification** to detect faults in models/policies. Some have only limited SOD (Separation of Duty) check.
- **Test-suite generation** for testing AC implementations in real operation environment to detect faults in implementations.

Future Work

- Available soon after final Alpha test.
- Enhance capabilities:

  -- White-box model/properties verification to verify coverage and confinement of AC rules.

  -- Additional AC policy templates including dynamic and historical access control models.

  -- API or mechanism for acquiring or consuming information about users, attributes, resources, etc.

Questions?

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