Misconfiguration Management of Network Security Components

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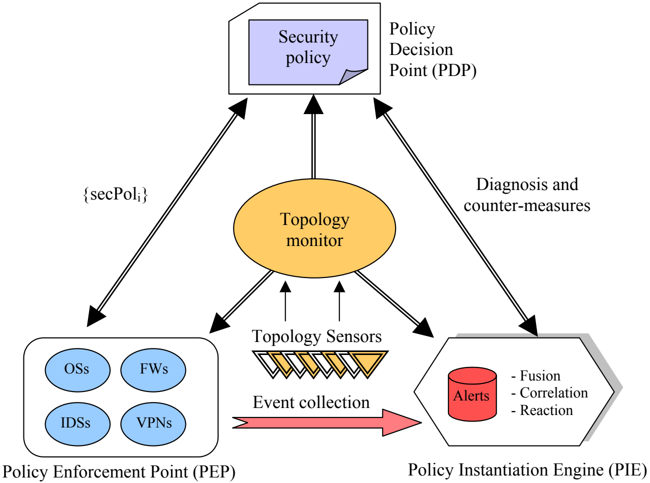
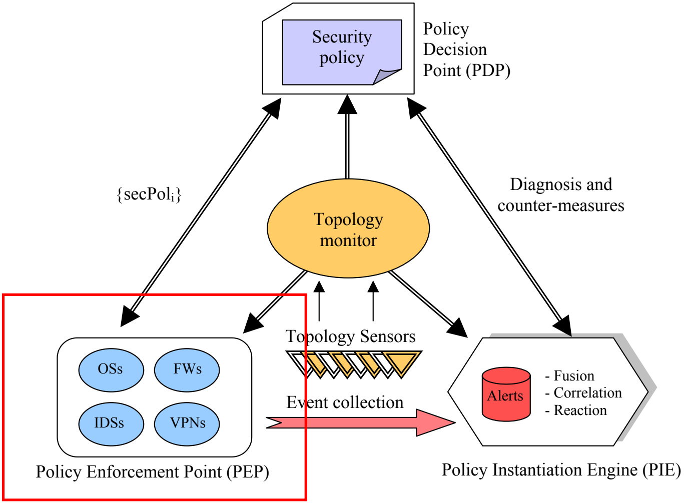
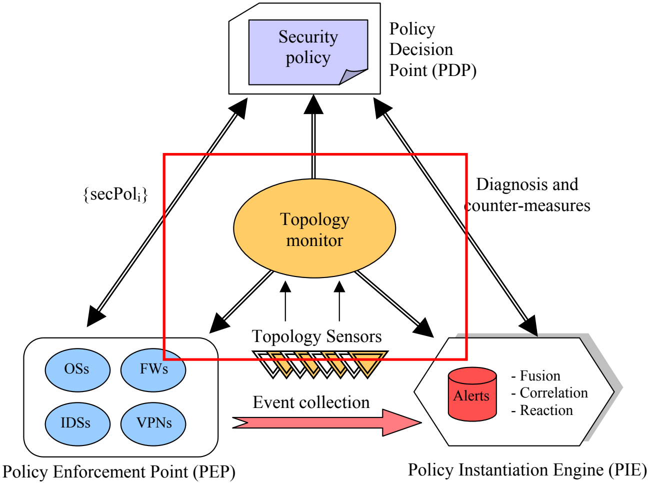
Introduction




Security policy
Policy Decision Point (PDP)
{secPol_i}
Diagnosis and counter-measures
Topology monitor
Topology Sensors
Event collection
OSs
FWs
IDSs
VPNs
Policy Enforcement Point (PEP)
Alerts
- Fusion
- Correlation
- Reaction
Policy Instantiation Engine (PIE)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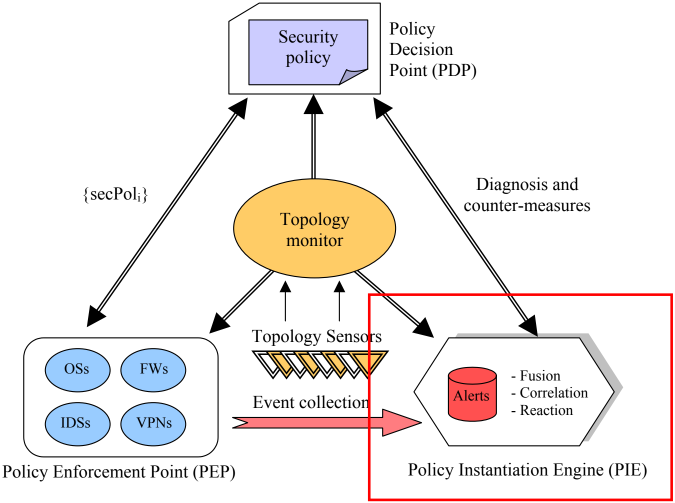
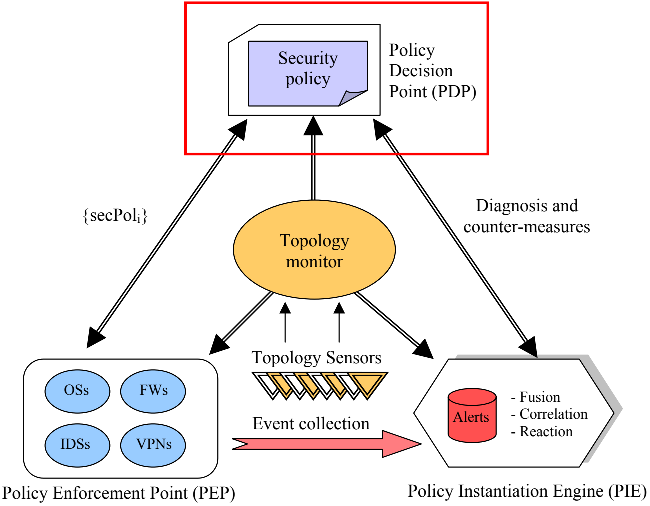
Introduction: Policy Instantiation Engine

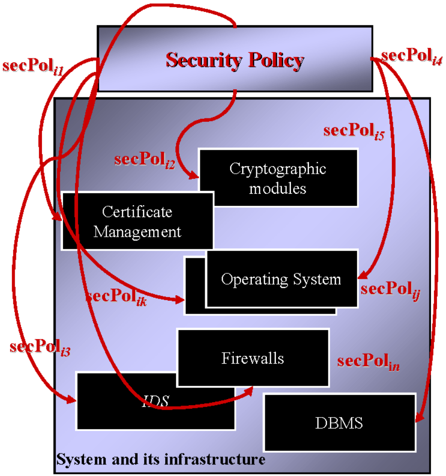


Introduction: Problem addressed here

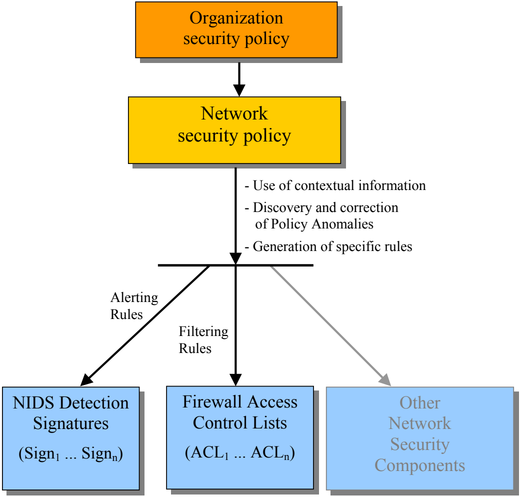


Introduction

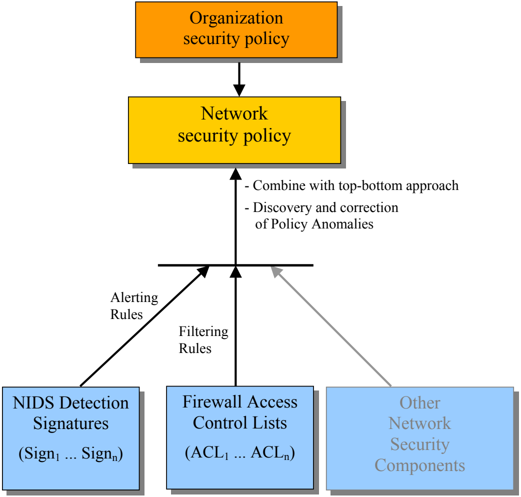
- Definition of a global security policy for the whole system
- Refinement process:
  - → Configuration of specific security policies according to each component within such a global security policy



Top-bottom approach



Bottom-top approach



Bottom-top approach

- We just point out to firewall's filtering rules:

$$Condition \rightarrow accept$$

$$or$$

$$Condition \rightarrow deny$$

  - Condition over a set of attributes

$$@source \wedge @destination \wedge sport \wedge dport \wedge protocol$$

  - Example:

$$s \in 1.0.0.0/24 \wedge d \in any \wedge p = tcp \wedge dport = 80 \rightarrow accept$$

Policy anomalies

- When processing packages, conflicts due to rule overlaps can occur within the filtering policy
- This conflict can be solved by ordering the rules
    - *First matching strategy*
- It introduces, however, other problems
    - Redundancy
    - Shadowing

Definitions

- Redundancy
  - Let R be a set of filtering rules, and let $r \in R$
  - Then, rule r is redundant in R iff we can remove r from R and the filtering policy does not change
- Example

$$R1 : s \in 1.0.0.0/24 \wedge d \in 2.0.0.0/16 \wedge p = tcp \wedge dport = 80 \rightarrow accept$$

$$R2 : s \in 1.0.0.0/24 \wedge d \in any \wedge p = tcp \wedge dport = 80 \rightarrow accept$$

Definitions

- Shadowing
  - Let R be a set of filtering rules, and let $r \in R$
  - Then, rule r is shadowed in R iff such a rule is never applied within filtering policy
- Example

$$R1 : s \in 1.0.0.0/24 \wedge d \in any \wedge p = tcp \wedge dport = 80 \rightarrow accept$$

$$R2 : s \in 1.0.0.0/24 \wedge d \in 2.0.0.0/16 \wedge p = tcp \wedge dport = 80 \rightarrow accept$$

Related Work

- Some algorithms has been proposed in order to detect such anomalies within a set of filtering rules
  - E. Al-Shaer and H. Hamed,
    Firewall Policy Advisor for Anomaly Detection and Rule Filtering
    Best paper award at IEEE/IFIP Integrated Management (IM'2003)
- Proposal:
  - Analyze all the pair of rules
- It does not detect, however, all the possible cases

Example of anomalies not detected

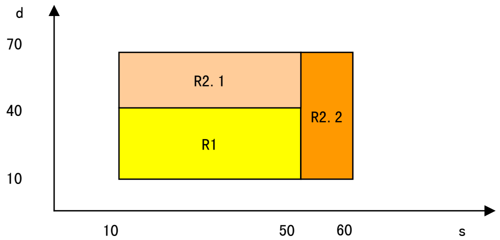
- Shadowing
  - $R1 : s \in 1.0.0.[10, 50] \rightarrow accept$
  - $R2 : s \in 1.0.0.[40, 90] \rightarrow accept$
  - $R3 : s \in 1.0.0.[30, 80] \rightarrow deny$
  - Rule $R3$ is never applied
- Redundancy
  - $R1 : s \in 1.0.0.[10, 50] \rightarrow deny$
  - $R2 : s \in 1.0.0.[40, 70] \rightarrow accept$
  - $R3 : s \in 1.0.0.[50, 80] \rightarrow accept$
  - Rule $R2$ is redundant

Our proposal

- Complete analysis based on rewriting of rules
    - F. Cuppens, N. Cuppens, and J. Garcï¿½a,
      Misconfiguration Management of Network Security Components
      7th Int. Symposium on System and Information Security (SSI05)
- Audit process of firewall setups:
    - → Detection: existence of relationships between attributes
    - → Removal: transformation from an initial set of rules
      to an equivalent one which rules free of dependencies

Removal of dependencies

- Example:
  - $R1 : s \in 1.0.0.[10, 50] \wedge d \in 2.0.0.[10, 40] \rightarrow deny$
  - $R2 : s \in 1.0.0.[10, 60] \wedge d \in 2.0.0.[10, 70] \rightarrow accept$
- Once applied our algorithm:
  - $R1 : s \in 1.0.0.[10, 50] \wedge d \in 2.0.0.[10, 40] \rightarrow deny$
  - $R2.1 : s \in 1.0.0.[51, 60] \wedge d \in 2.0.0.[10, 70] \rightarrow accept$
  - $R2.2 : s \in 1.0.0.[10, 50] \wedge d \in 2.0.0.[41, 70] \rightarrow accept$



Detection of redundancy and Shadowing

- Two phases

  $\rightarrow$ Phase 1: rewriting when decision is different
  $\rightarrow$ Phase 2: rewriting when decision, after test of redundancy, is the same

Example:

$R1 : s \in [10{,}50] \rightarrow deny$

$R2 : s \in [40{,}90] \rightarrow accept$

$R3 : s \in [60{,}100] \rightarrow accept$

$R4 : s \in [30{,}80] \rightarrow deny$

$R5 : s \in [1{,}70] \rightarrow accept$

Detection of redundancy and Shadowing

- Two phases

  $\rightarrow$ Phase 1: rewriting when decision is different

  $\rightarrow$ Phase 2: rewriting when decision, after test of redundancy, is the same

Phase 1 : rewriting R2/R1

R1 : s $\in$ [10,50] $\rightarrow$ deny

R2 : s $\in$ [51,90] $\rightarrow$ accept

R3 : s $\in$ [60,100] $\rightarrow$ accept

R4 : s $\in$ [30,80] $\rightarrow$ deny

R5 : s $\in$ [1,70] $\rightarrow$ accept

Detection of redundancy and Shadowing

- Two phases

  → Phase 1: rewriting when decision is different
  → Phase 2: rewriting when decision, after test of redundancy, is the same

Phase 1 : rewriting $R5/R1$

$R1 : s \in [10,50] \rightarrow$ deny
$R2 : s \in [51,90] \rightarrow$ accept
$R3 : s \in [60,100] \rightarrow$ accept
$R4 : s \in [30,80] \rightarrow$ deny
$R5.1 : s \in [1,9] \rightarrow$ accept
$R5.2 : s \in [51,70] \rightarrow$ accept

Detection of redundancy and Shadowing

- Two phases
  - $\rightarrow$ Phase 1: rewriting when decision is different
  - $\rightarrow$ Phase 2: rewriting when decision, after test of redundancy, is the same

Phase 1 : rewriting R4/R2

$R1 : s \in [10,50] \rightarrow$ deny

$R2 : s \in [51,90] \rightarrow$ accept

$R3 : s \in [60,100] \rightarrow$ accept

$R4 : s \in [30,50] \rightarrow$ deny

$R5.1 : s \in [1,9] \rightarrow$ accept

$R5.2 : s \in [51,70] \rightarrow$ accept

Detection of redundancy and Shadowing

- Two phases
  - $\rightarrow$ Phase 1: rewriting when decision is different
  - $\rightarrow$ Phase 2: rewriting when decision, after test of redundancy, is the same

Phase 2 : rewriting R4/R1

R1 : s $\in$ [10,50] $\rightarrow$ deny

R2 : s $\in$ [51,90] $\rightarrow$ accept

R3 : s $\in$ [60,100] $\rightarrow$ accept

R4 : $\emptyset$ $\rightarrow$ deny R4 is shadowed

R5.1 : s $\in$ [1,9] $\rightarrow$ accept

R5.2 : s $\in$ [51,70] $\rightarrow$ accept

Detection of redundancy and Shadowing

- Two phases

  → Phase 1: rewriting when decision is different
  → Phase 2: rewriting when decision, after test of redundancy, is the same

Phase 2 : redundancy test over R2

$R1 : s \in [10,50] \rightarrow deny$

$R2 : \varnothing \rightarrow accept$ R2 is redundant

$R3 : s \in [60,100] \rightarrow accept$

$R4 : \varnothing \rightarrow deny$ R4 is shadowed

$R5.1 : s \in [1,9] \rightarrow accept$

$R5.2 : s \in [51,70] \rightarrow accept$

Detection of redundancy and Shadowing

- Two phases
  - → Phase 1: rewriting when decision is different
  - → Phase 2: rewriting when decision, after test of redundancy, is the same

Phase 2 : rewriting R5/R3

$R1 : s \in [10,50] \rightarrow \text{deny}$

$R2 : \varnothing \rightarrow \text{accept}$ — R2 is redundant

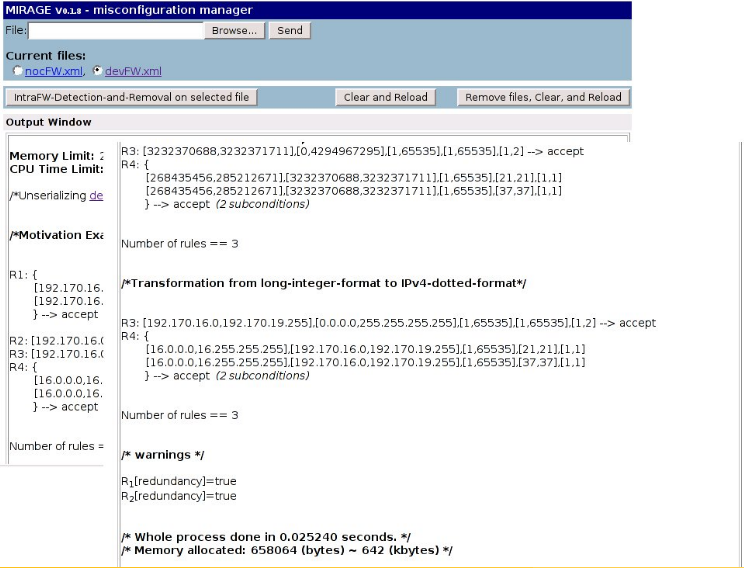
$R3 : s \in [60,100] \rightarrow \text{accept}$

$R4 : \varnothing \rightarrow \text{deny}$ — R4 is shadowed

$R5.1 : s \in [1,9] \rightarrow \text{accept}$

$R5.2 : s \in [51,59] \rightarrow \text{accept}$

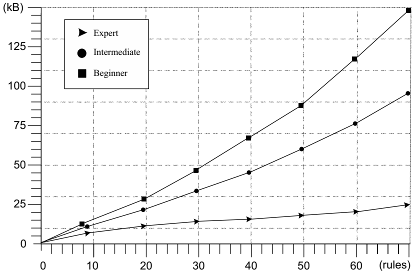
Implementation of a first prototype



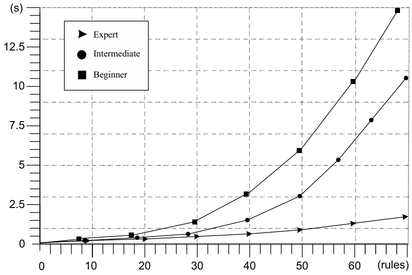
Deployment and evaluation

- Carried out on an **Intel-Pentium M 1.4 GHz** processor with **512 MB RAM**, running **Debian GNU/Linux 2.6.8**, and using **Apache/1.3** with **PHP/4.3** interpreter configured

Memory space



Processing time



Conclusions

- Audit process of firewall setups to both detect and eliminate configuration anomalies
  - $\rightarrow$ Detection: existence of relationships between attributes
  - $\rightarrow$ Removal: transformation from an initial set of rules to an equivalent one which rules free of dependencies
- Implementation in a software prototype
  - $\rightarrow$ It demonstrates the practicability of our work
  - $\rightarrow$ Although the evaluation points to strong requirements, it is reasonable for off-line analysis