Hybrid Rule Threshold Adjustment System for Intrusion Detection

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Outline of the Presentation

- Introduction
- Background
- Our Proposed Framework
- Testing and Evaluation
- Conclusions
- Questions from Audiences

Motivation

- Challenge:
  - Huge volume of Alerts Generated by Security Devices such as IDSs (It is hard to make sense out of a large pile of alerts!)

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we need alerts correlation

  - Computer Networks are changing over time. (Correlation rules become out of tune!)

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Rule-based Alert Management System should be adapted to this changing

- Solution:
  - Automatic Rule Adjustment

Alert Management System Adaption

- This Adaption can be achieved by adjusting the existing rules.
- Two types of automatic adjusting of the rules can be used:
  - Rule Structure Refinement.
  - Rule Threshold Adjustment.
- But, which one is more suitable solution?!!!

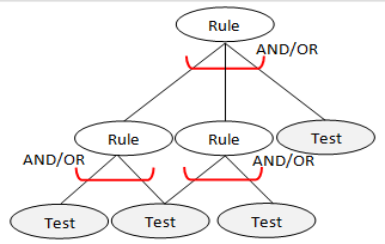
Rule Threshold Adjustment (cont..)

- Can be breakdown into
  - Online Threshold Adjustment.
  - Offline Threshold Adjustment.
- Aim: to develop a *Hybrid Rule Threshold Adjustment System* (HRTA) .

Background: Rule (Correlation Rule)

- Definition: a logical combination of conditions which if satisfied leads to triggering of actions specified by that rule.
- Every rule consists of two main parts:
  1. *Condition* part
  2. *Action* part
- The condition part of a rule consists of logical combination of tests and other rules.
  - Test Definition: a Boolean function defined on an input parameter
    - Numerical parameter such as IP, Port Number,…
    - Descriptive parameter such as attack type,…

Background: Rule ----(cont.)



Typical Rule Structure

Background: Existing Works on Rule Adjustment

- Rule Structure Refinement

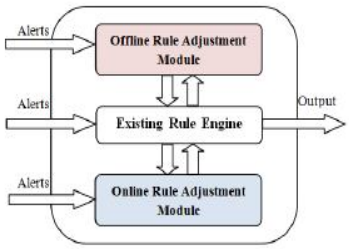
1. **SEEK and SEEK2**
   - Automatic knowledge-base refinement system
   - adding, deleting, or altering the rule-components in a knowledge base system.
2. **FOIL , GOLEM , and SILT**
   - based on the inductive logic
3. **TopGen**
   - Extension of KBANN

Background: Existing Works on Rule Adjustment (cont.)

- Are these solutions adequate?
  - rules are generated based on the expert knowledge and we can not modify their structure.
  - rules are very specific to catch certain attacks or network misconfiguration.
  - So, Unfortunately, **No**!!!!
- We need to design a new system which will be able to adjust the thresholds inside the rules based on the current environment of the network.
- To the best of our knowledge, no previous work on Rule Threshold Adjustment has been reported.

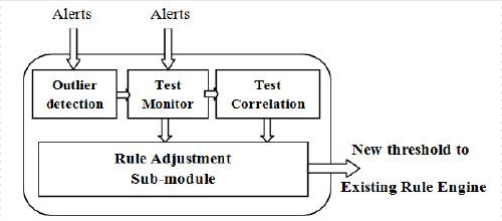
HRTA Framework

- Online adjustment:
  - more memory efficient and fast
  - prone to small error.
- offline adjustment
  - more memory and CPU intensive
  - more accurate.



Online Part

- Comprised of three steps:
  1. Monitor tests behavior to detect network changes.
  2. Determine whether the change is stable or not.
  3. Compute the new threshold.

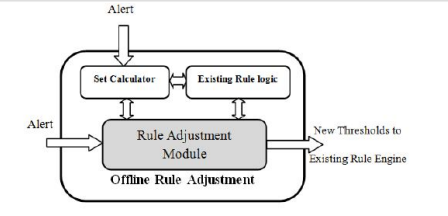


Online part

- For more details please see:
  - M.M.Moghimi, M Saraee, " A New Framework for Online Rule Threshold Adjustment in Intrusion Detection" IEEE CSI/ CSSE (2011).

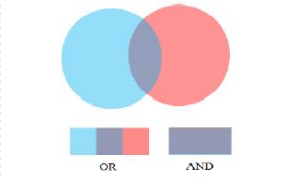
Offline part modules

- Set calculator: event set calculation for each of the rules and tests.
- Existing rule logic: holds the rules hierarchy that we are going to adjust.
- Rule adjustment: holds the offline adjustment algorithm



(Event) Set Calculator

- This calculation can be done by considering rule hierarchy!
- OR Condition: Union of the children sets
  - parent node inherits the number of events resulting from all children nodes
- AND Condition : Intersection of the children sets
  - the parent node gives at most the smallest event set of any of the children



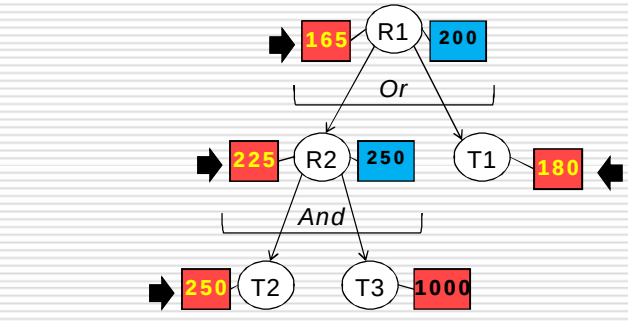
Adjustment algorithm for offline-part Adjustment(x)

```
1.  event_set= event_set_computation(x); // initial event set computation based on DFS

2. if (|event_set| > optimal_threshold(x))
    do{
       for(each branch of the node)
          if (a branch has OR condirion)
            node =select_L(x);//select child node of x with the largest set
          if (a branch has AND condition)
             node =select_S(x);// select child node of x with the smalles set
       if(node is a leaf) test_adjustmnet(node);
       else adjustment(node);
       new_event_set= event_set_computation(x);
    }until(|new_event_set|<= optimal_threshold(x))

3. add_to_rule_logic(x);  existing rule logic update with new thresholds
```

Example



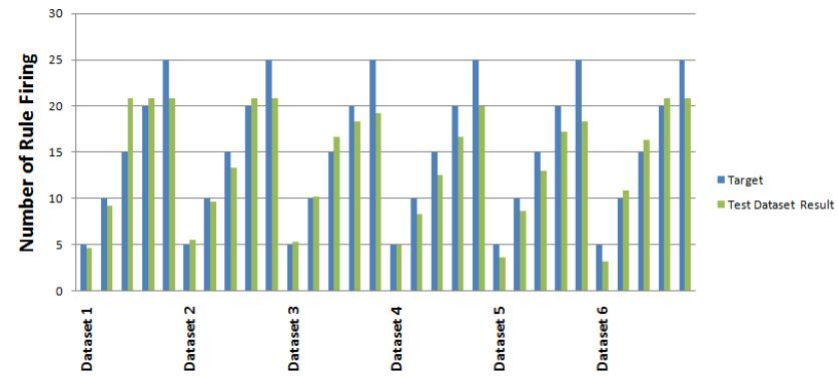
Cardinality of the event set for the node

Optimal Threshold for the node

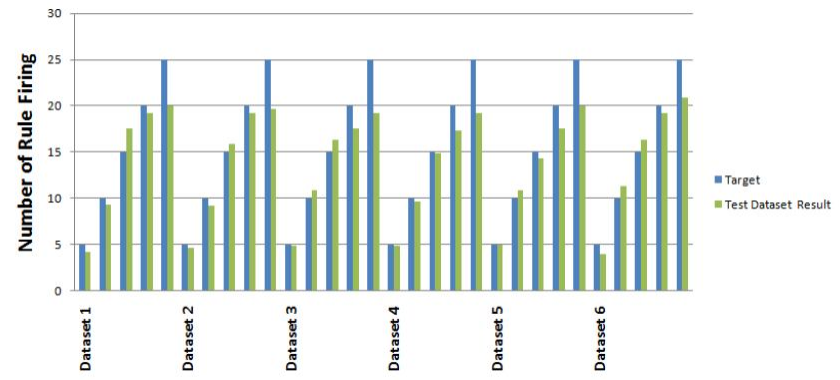
Case study: Testing and Evaluation

- Datasets:
  - We have prepared seven datasets.
    - real-world network events
    - collected from the internal university network.
  - Six of the datasets are 4hours long and one of them is 24 hours long.
- Testing Process:
  - We used two different rule-sets that we adjusted based on six different datasets with five different rule firing targets.
  - After finishing each run, we have checked the new set of thresholds and the final number of rule firings on the test dataset, which is twenty-four hours long.

Results for Rule-Set 1



Results for Rule-Set 2



Conclusions

1. Alert management systems needs to be adapted as a result of network gradually changes.
2. This Adaption handled by Rule Threshold Adjustment.
3. HRTA consist of:

- The online part
  - receives a stream of alerts, monitors them for detecting changes, and based on the them adjusts the thresholds inside the corresponding rules
  - more memory efficient and fast but prone to small error.
- The offline Part
  - the offline part module receives a set of alerts repeatedly, to adjust the thresholds of the rules and to reach an optimal number of rule firing.
  - more memory and CPU intensive but more accurate.

Thank you for your attention!

Any Questions Please,

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