Collaborative Incident Handling Based on the Blackboard-Pattern

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Foreword

- Presentation based on slides from *3rd Workshop on Information Sharing and Collaborative Security (WISCS 2016)* held in conjunction with *23rd ACM Conference on Computer and Communications Security (CCS)*
- Added for today: Future work on security and privacy aspects of the blackboard

Motivation and Background

Related Work and Problem Statement

System Design and Implementation

Evaluation

Future Work: Security and Privacy

Conclusion

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Motivation

- Amount and variants of attacks on networks is growing
- Defending networks manually is impossible
- Automated incident handling is highly beneficial
  - Continuously defend the network
  - Respond quickly
  - Less error-prone
  - Systematical incident response

Background: Typical Intrusion Handling Steps

- Network Monitoring (NMS) and Intrusion Detection Systems (IDS) collect information about the network and its healthiness
  - NMS: collect infrastructure information
  - IDS: raise alerts when an intrusion is detected
- Alert Processing Systems (APS) aggregate, correlate and prioritize alerts
  - Gain more insights into the intrusion by analyzing the situation
- Intrusion Response Systems (IRS) counteract automatically
  - Identify suitable responses
  - Execute reponses on the target network, e.g., block a rogue host

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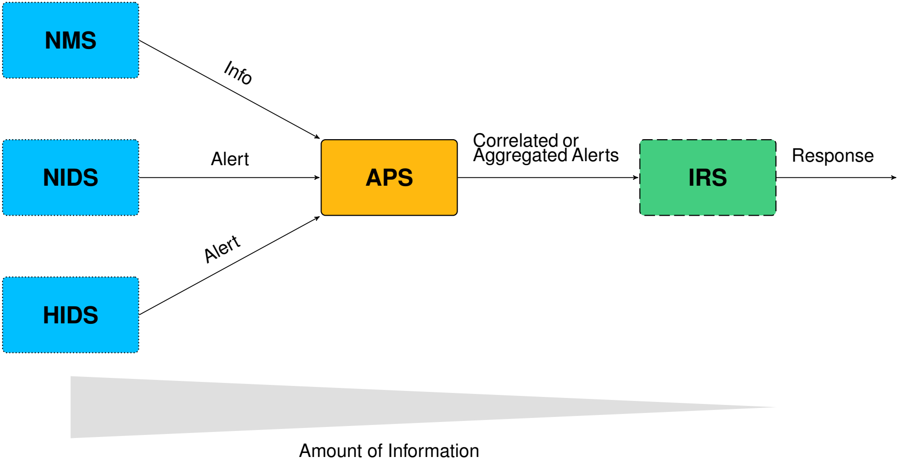
Execution Model: Pipelined Intrusion Handling



Problem Statement

- Significant effort has been made to improve each intrusion step individually
- No solution exists that interleaves steps and creates a comprehensive view on the target network
  - Information already collected/computed in previous steps is lost for being used by subsequent steps
  - Information and intermediate results cannot be shared efficiently between single steps

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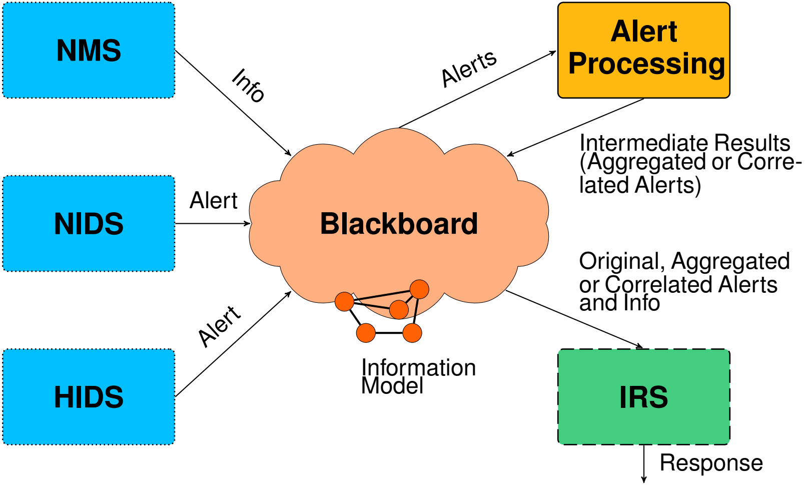
Introducing the Blackboard Pattern

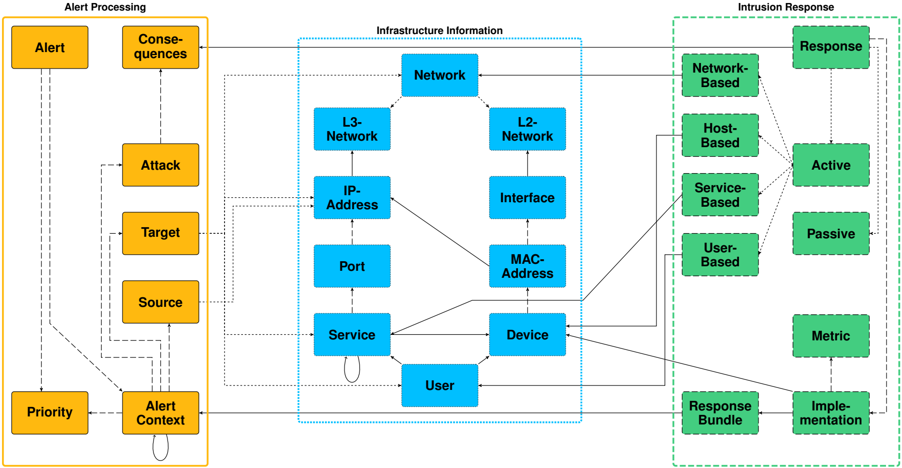
- The blackboard pattern is applicable to problems that can be decomposed into smaller sub-problems / sub-tasks
  - Example: (distributed) incident handling / intrusion handling
- Sub-tasks solve their sub-problem and share their intermediate results with other sub-tasks
- Original information remains untouched
- Original information + intermediate results can be reused by sub-tasks to further tackle the problem

- Blackboard needs an Information Model specifically designed for the problem domain

Blackboard-based Intrusion Handling


NMS
Info
Alerts
Alert Processing
Intermediate Results (Aggregated or Correlated Alerts)
NIDS
Alert
Blackboard
Alert
HIDS
Original, Aggregated or Correlated Alerts and Info
Information Model
IRS
Response

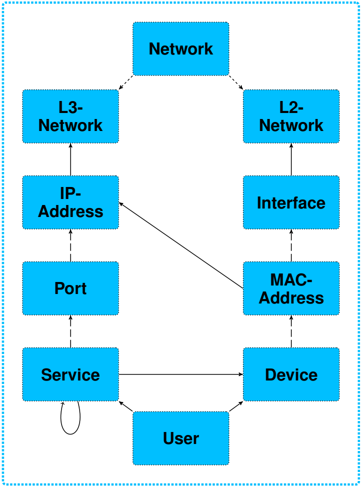
Information Model for Intrusion Response - Overview



Infrastructure Information Model – Examples

- NMSes send their scanning results to specific interfaces which add the info to the Blackboard
- A `Service` runs at a `Port` opened on a NIC with an `IP-Address` belonging to a `L3-Network`
- A `Device` has a `NIC` with `MAC-Address` and assigned `IP-Address`
- A `User` is logged into `Device`
- A `User` uses `Service`

Infrastructure Information



Implementation

- Python 3
- Object oriented implementation of Information Model
- Automatic translation of class structures to suitable database design
- Two different databases/database types used:
  - Relational: postgreSQL
  - Graph-based: OrientDB

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Evaluation – Test Data Sets and Test Cases

→ Measure the prototype's performance under varying conditions

- Test data sets simulate different attacks:

DDoS DDoS: many sources attack a small number of targets
AP Attack path: an attack spreads in the network
F Flooding: Mulitple IDSes raise the same alert

- Test data set size: from 1000 to 5000 alerts

- Test cases simulate typical tasks of the intrusion handling system

ins Node Insertion – Adding of `Alert` and `Alert Context` nodes
prio Node Prioritization – Updates `Priority` attribute of `Alert` and `Alert Context` nodes with random number
comb Node Combination – Combining related `Alerts Context` nodes

- Test cases are cumulative, e.g., t3 contains t1 and t2

Measurement Results: Alerts per Second

Exp.	$pSQL_{min}$	$pSQL_{max}$	$pSQL_{avg}$	$Orient_{min}$	$Orient_{max}$	$Orient_{avg}$
$DDoS_{ins}$	287.09	354.72	320.75	11.4	19.72	14.73
$DDoS_{prio}$	228.61	307.27	257.8	8.4	16.24	11.55
$DDoS_{comb}$	64.97	125.44	86.15	1.37	6.75	3.12
AP_{ins}	299.4	355.76	324.76	12.5	19.35	15.13
AP_{prio}	230.36	287.86	250.71	8.91	16.23	11.62
AP_{comb}	30.80	85.12	49.59	0.51	3.01	1.1
F_{ins}	370.32	396.63	384.58	37.88	50.87	44.77
F_{prio}	318.1	330.31	325.04	15.4	35.29	23.38
F_{comb}	281.78	293.31	287.73	14.13	18.00	16.97

Table contains min, max and average rates of all test data set sizes

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Authenticity, security and privacy

- ... of the information in the BB is important
- Authenticity: faked information might trigger IRS to counteract in a manner beneficial for the attacker
  - E.g.: Shut down VM, disconnect network, etc. → DoS-like effect
- Security: leaked information might provide helpful insights for an attacker
  - E.g.: Network structure, targets, weaknesses, defense mechanisms
- Privacy: information in the BB might be related to persons and needs sufficient protection
  - E.g.: MAC address of a personal device identifies person

→ We need to protect the BB's data from rogue Modules

DB Security Orchestration by Blackboard Controller

- Authentication of Modules
  - Module obtains SSL certificate
  - Authenticates towards Controller
  - If needed: integrity checks possible (Remote Attestation)
  - BB Controller creates transient username/password for this Module

  → Generally applicable for each module

- Fine-grained DB access control:
  - Controller additionally sets specific DB permissions for a Module
  - R/W access to specific DB tables / DB table attributes
  - Creation of specific DB views for Module
  - Stored procedures, e.g., for querying aggregated values

  → Permissions/other options vary for different Modules and also the used DB

Can we additionally protect against server-side attacks?

- We still have a central collection of sensitive data on a server
- Server might be attacked → Can we use a cryptographic DB?
- Example: ZeroDB
  - + Only encrypted information on DB server
  - - Query logic shifted to clients
  - - Decreases performance by some magnitues (esp.: latency)
  - - Only small subset of SQL features availiable, e.g., no views
  - - Implementation so far only single user; no information sharing

→ Alternative: partially encrypt highly sensitive information with CP-ABE, etc.

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- Related work has drawbacks: information sharing is difficult between intrusion handling steps, information loss, ...
- **Our contributions:**
  - Blackboard-pattern for intrusion handling
  - Suitable information model
  - → Enables Information sharing between intrusion handling steps
  - Proof-of-concept implementation using two different DBs
- Future Work:
  - Information security of the data on the Blackboard
  - Improving performance

Contact

Thank you for the audience!

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https://github.com/Egomania/BlackboardIDRS