Integrated Visualization of Network Security Metadata from Heterogeneous Data Sources

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Motivation

Problem in Network Security

- Typical networks consist of various components like user endpoints, network security devices, services, ...
- Information is not shared among those components.
- Thus, an overview of *whats going on* is difficult.

Exemplary Use-Cases

- Detect combinations of failed login attempts on multiple services by the same user.
- Find the sources of the attack.
- Trace the way the attack *moved* in the network.
- React fast by shutting down accounts or locking out devices.

Our Contribution

- Design and implement an integrated visualization, that works with data from various sources, and helps to detect and react to such attacks.

Requirements

Real-Time Monitoring

- Acquire knowledge before it is outdated
- → Allows for faster reactions after detection of abnormal behavior

Data Integration

- Combine information and knowledge from arbitrary components
- → Allows to combine knowledge

Retrospective Analysis

- Preserve historical course of data and provide means to navigate in time
- → Events that led to a specific state can be retracted

Integration of Data Sources

Types of data interesting for network security

- Physical and logical topology
- Configuration of devices & services
- State
- Behavior

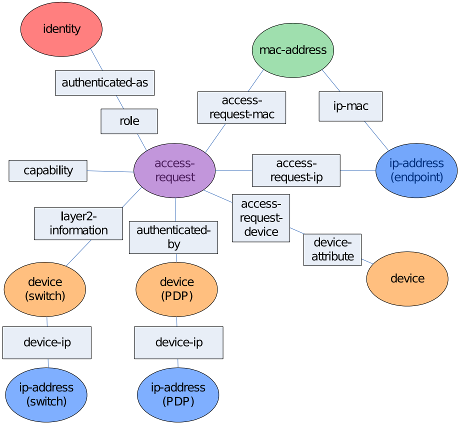
Our approach

- Use IF-MAP protocol as the foundation (→ next slides)

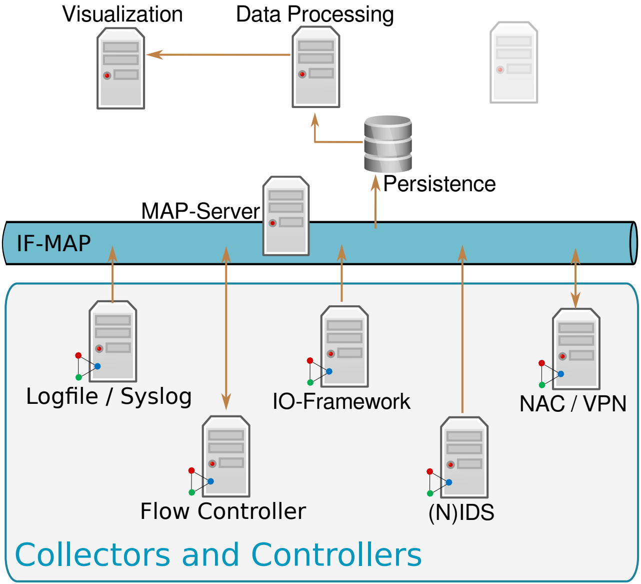
Interface for Metadata Access Points (IF-MAP)

What is it?

- Open specification by the Trusted Computing Group
- Goal: allow exchanging information between arbitrary network components
- Data is defined in an extensible way and not bound to a domain



Proposed Architecture



Application and Persistence Level Concepts

Enhancements to IF-MAP

- Persistence of IF-MAP data, as the MAP server only holds the current state

Continuous recording

- Preserve the *changes* (not only snapshots) as the MAP server receives them

State and change queries

- Allow to query for *snapshots*, i.e. the complete graph at a given time
- Allow to query for the *changes* (delta) between two timestamps

Visualization Requirements and Concepts I

Representing the data model

- IF-MAP forms a graph with nodes (identifier) and edges (links) and information attached to them
- Thus can be rendered with standard graph rendering techniques and layouts

Publisher distinction

- The source (i.e. the MAP client *measuring* the data) of metadata needs to be transparent to the user
- Use the IF-MAP *publisher-id* to distinct between metadata from different clients (e.g. by coloring)

Visualization Requirements and Concepts II

History navigation

- Navigation via three modes: *live view*, *history view*, *delta view*
- Selection of timestamps via *slider* and/or forward-backward-buttons

Search Functionality and Filtering

- Allow the user to search or filter the graph data, to pinpoint a single node or a selection of nodes with similar features
- Search results can either be highlighted or colored differently as non-matching nodes
- Non-matching nodes also can be shown translucent, to retain the overall structure

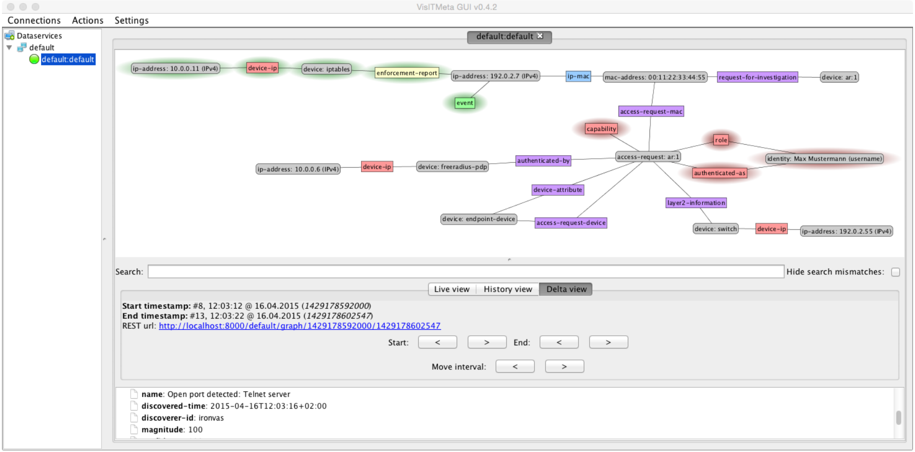
VisITMeta Application

General information

- Research project, funded by German Ministry for Research and Education
- Released as open-source software[1]
- Implementation of all previous concepts
- Offers additional features like motion control (LeapMotion)

[1] https://github.com/trustathsh/visitmeta

Screenshot (v0.4.2)



Search:

Hide search mismatches: □

Start timestamp: #8, 12:03:12 @ 16.04.2015 (*1429178592000*)
End timestamp: #13, 12:03:22 @ 16.04.2015 (*1429178602547*)
REST url: http://localhost:8000/default/graph/1429178592000/1429178602547

name: Open port detected: Telnet server
discovered-time: 2015-04-16T12:03:16+02:00
discoverer-id: ironvas
magnitude: 100

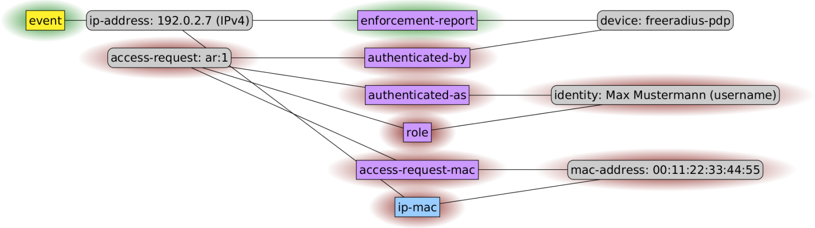
Specifics of IF-MAP Visualization

Characteristics of IF-MAP graphs

- Two kinds of nodes: Identifier and Metadata
- Can and should be handled differently when calculating layouts

Example: Adapted Bipartite Layout

- Identifier in columns 2 and 4, Metadata in columns 1, 3 and 5
- Emphasizes the difference between link and single metadata



Results

Homogenization

- IF-MAP used for acquisition and homogenization of different data sources
- Components need only be enabled to publish IF-MAP information

Data context

- Implicit connection of different data like network addresses, user credentials, services and high-level events

Interoperability

- VisITMeta as a software is usable in every IF-MAP-based environment as it uses standard mechanisms to fetch the data
- Many MAP clients and thus a good amount of data sources already available

Continuous recording and retrospective analysis

- Changes are persisted as they are processed by the MAP server
- They can then be reconstructed step by step

Indentified Challenges

Visual Scalability

- Big graphs get cluttered really quick
- Techniques to reduce the size of the graph have to be added, like Level of Detail

Visual dynamics

- Frequent changes in the network lead to many changes in the visualization
- E.g. do not show low-level data and concentrate instead on high-level abstractions

Recording of all data

- Mechanism to fetch data from the MAP server has a shortcoming implied from IF-MAP itself: only connected graphs can be observed via a *subscription*
- IF-MAP does not offer a mechanism to get to know if there are new and disconnected graphs.

Conclusion

Summary

- Requirements for data integration including model and requirements for visualizing the data
- IF-MAP as foundation
- Graph-based visualization with regards to IF-MAP structure
- Features like history navigation and filtering

Future Work

- Address the identified challenges
- Using data persistence for analysis