Towards Provable Network Traffic Measurement and Analysis via Semi-Labeled Trace Datasets

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Research Problems

challenges that everyone has to deal with

- Lack of **research standards**

  missing rules for research data collection, analysis, sharing, and ethics of usage

- Inaccessibility of **appropriate datasets**

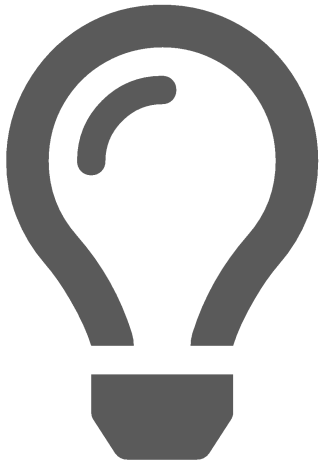
  real-world data cannot be reliable annotated and needs to be anonymized, artificial data are not sufficiently realistic and provides a limited set of network traffic

- Inability to **prove research results**

  it is complicated to prove properties of the proposed analytical method leading to limited acceptance of the results by industry

- Missing **verification** of others researchers' results

  data and algorithms are kept in private which leads to the impossibility of research reproducibility



The Basic Idea

what we realized during our research

- **Single event** full packet capture can be publicly shared

  units of network traffic with one type of network event contains only a minimum of personal data and can be publicly shared and easily annotated

- Packet capture can be **„simply“ manipulated**

  MAC and IP addresses can be changed to predefined values together with capture time and subsequently adapted to real-world data

- Events can be **mixed with each other** or with real-world data

  we usually have access to the real-world data, but we need an annotation or a ground truth

Towards Provable Network Traffic Measurement and Analysis via Semi-Labeled Trace Datasets

our goal is not to deal with all identified problems at this point, but to present a general solution in order to start a discussion of its usability

Semi-Labeled Datasets

we aim to cover all areas relevant to datasets usage

1. **Creation** of annotated units
2. **Use of semi-labeled datasets** composed of annotated units
3. **Sharing platform** for annotated units
4. Use of semi-labeled datasets for a **research evaluation**

Challenges of Shared Datasets

usage and creation requirements to support applicability

- Data **anonymization**

  problems of application data and consistency in all packet layers

- Traffic **annotation**

  either inaccurate annotation of real-world datasets or accurate annotation of an artificial dataset but with insufficient authenticity

- Capture **parameters**

  network topology, capacity, utilization, and latency affects the dataset creation

- Dataset **recency**

  each fixed dataset becomes obsolete in time

Annotated Units

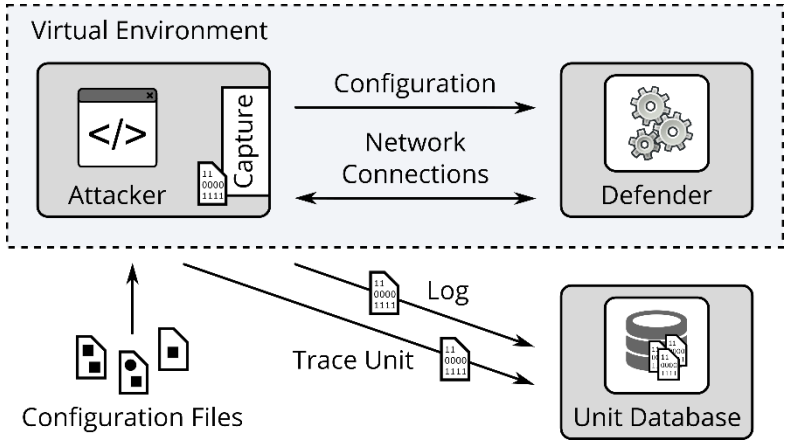
normalized and annotated packet traces containing a single event

Creation of full packet traces

- filter the desired traffic from an existing network
- capture a traffic form a prepared environment

Packet trace **normalization**

- change MAC and IP addresses to predefined values
- reset timestamp to zero epoch time



Units **annotation**

- store information about author, capture interface, network settings, and trace content

github.com/CSIRT-MU/trace-share

Annotated Units

besides benefits, there are still issues that need to be addressed

- **No sensitive content** of a traffic
- Accurate **annotation**
- Easily accessible **data recency**

- **Uniformity** of virtual environment
- **Normalization** problems
- Trace **consistency** preservation

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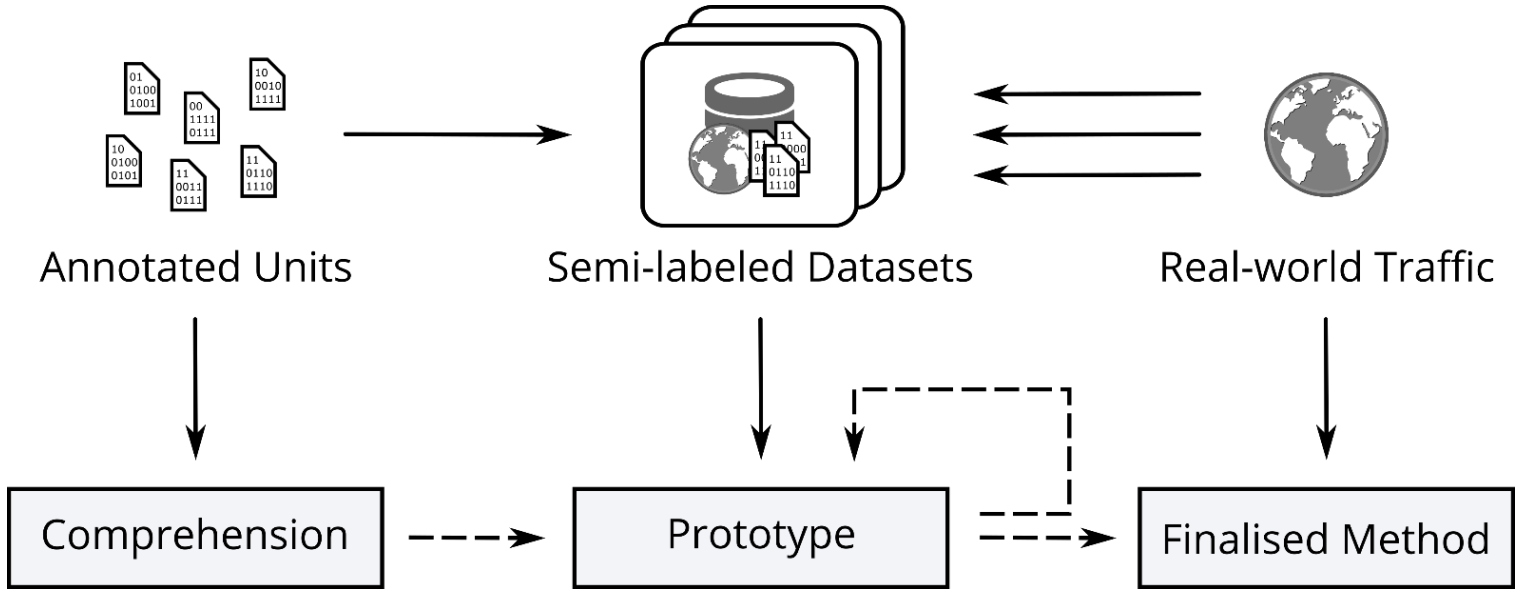
Combination of Annotated Units

how to create a semi-labeled dataset

1. **Select** annotated units based on your interest
2. **Capture** real-world network traffic within your environment
3. **Compute** characteristics of the real-world traffic capture
4. **Modify** annotated units to reflect characteristics of the real-world traffic
5. **Merge** annotated units and real-world traffic capture

Usage of Semi-Labeled Datasets

development of analytical methods using annotated units



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Sharing Platform Challenges

each of dataset sharing platforms suffers from common issues

- Data **anonymization**

  assisted anonymization of uploaded datasets should be one of the key features of a central dataset sharing platform

- Data **heterogeneity**

  sharing platform should have clearly defined types and format of datasets it collects

- Platform **sustainability**

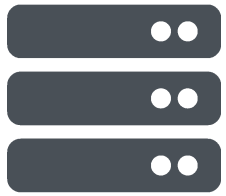
  a necessity to have a founding and create the platform as an open community hub

- Initial **content**

  sharing platforms should contain a sufficient number of up-to-date datasets when launched

Data Sharing Platform

our plans with trace·share open platform



- **Community** hub
- **Storage and management** of annotated units
- **Assisted** uploading, normalization, annotation, and mixing of annotated units

- Inspired by OpenML platform (see https://openml.org)
- Prototype available at the end of the year (see https://github.com/CSIRT-MU/traceshare)

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Challenges of Research Evaluation

an evaluation must give an objective metric of the method efficiency

- **Qualitative** aspect

  properties of a dataset itself whereas the network traffic capture must contain realistic, diverse data, that accurately reflect real-world traffic

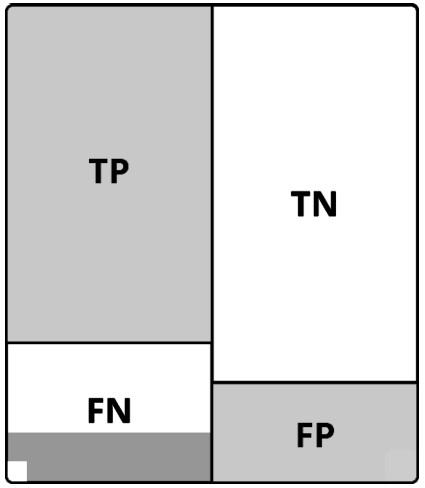
- **Quantitative** aspect

  the process of evaluation giving an objective metric of the method efficiency, typically using confusion matrix with true positive, false positive, and false negative values

Evaluation Using Semi-Labeled Dataset

combination of qualitative and quantitative aspects

- **Ground truth** of the dataset based on inserted annotated units
- **Balanced** quantitative and qualitative aspects
- Unknown positives need to be **verified manually** and shared



- Annotated units
- Identified events
- Other identified units
- Uncertainty

Semi-Labeled Datasets in a Nutshell

quick conclusion and a discussion of possible problems, solutions, (crazy) ideas, or anything else

Summary

what you should remember from this presentation

- No need to share the entire network traffic, **share only selected events!**
- **Combine events** between themselves and with real-world traffic
- **Share your differences** and provide annotated units to others
- **Prove** your research results!

- If you are interested in this topic contact me at **cermak@ics.muni.cz**

trace share
by CSIRT-MU

Prove your research by shared trace!

https://github.com/csirt-mu/trace-share

@csirtmu

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