Attack Forecast and Prediction

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Introduction

- Attackers seem to have a first mover advantage\textsuperscript{[1]} in a "dynamic cat and mouse game"\textsuperscript{[2]}

- A main goal should be the minimization of this first mover advantage - Attack forecasting and prediction however is only hardly used\textsuperscript{[3]}

- Projecting and predicting future developments furthermore is oftentimes based on experiences, subjective perceptions and gut feelings of experts
  - Prone to biases
  - Time consuming

- Low levels of automation in attack forecasting
Motivation

- “Although many solutions have been proposed, there is still no definite answer on how to effectively and precisely predict cyber attacks.”[3]

- Predictions mainly focus on a short term horizon rather than a medium- to long-term horizon

- Attack prediction and forecasting “is still an open and an imperative, desirable research problem”[3]
Cyber Threat Intelligence (CTI) defines structured, actionable information for identifying adversaries and their motives, goals, capabilities, resources and tactics.\[^2\]

- Powerful means of increasing the efficiency and automation of various security solutions
- CTI can be used for automated reasoning (data driven analytics) in cyber risk management
  - Threat Hunting; Attack detection; Attack prediction; Forensic investigations
- Importance of CTI lies in its ability to share threat information among partners \[^2\]
  - streamlined and structured information sharing
  - Structured Threat Information eXpression (STIX language) as a standard language for sharing CTI
- Objectives
  - Technical CTI
  - Operational CTI
  - Tactical CTI
  - Strategic CTI
- Levels
- Formats
- CTI
Research objectives

- Can any patterns or trends be extracted form CTI and used for crafting strategic medium to long term predictions on the threat landscape?

- How do different algorithms perform to predict future malware in a medium to long term?

- Can graph analytics be used to increase automation and precision in attack prediction and forecasting

Contributions

i. Utilizing CTI to infer automatically and improve hypotheses on new attacks

ii. Achieving a higher level of automation by automatic construction of hypotheses, supporting the analyst's decisions, saving scarce time

iii. Improving the accuracy of hypotheses provided by an analyst (minimizing biases due to subjective perspectives)

iv. Providing medium- to long-term predictions
Methodology

Generating test and training dataset

Evaluation

Cyber threat knowledge graph

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Cyber Threat Knowledge Graph

• Multi-level threat ontology based on CTI scraped from MITRE ATT&CK
• Analyzed relying on different algorithms for graph analytics for crafting attack predictions and forecasts

• Each Malware (M) can be described as a combination of techniques (T)

Statistics

▪ MITRE ICS, Enterprise & Mobile
▪ 13 tactics
▪ 552 techniques
▪ 585 different softwares (malwares)
Dataset splitting

- Excluded "degenerated" malware
  - 449 remaining attacks – malware

- Data was time sorted

- 80/20 - splitting
  - Training set: 358 oldest attacks of
    - 31.5.2017 - 10.6.2020
  - Test/evaluation set: 91 newest attacks
    - 10.6.2020 - 13.4.2021
Algorithms for forecast and prediction generation

- Classical graph analytic algorithms
  - Hierarchical Clustering
  - Principal Component Analysis
  - Time series and regression analysis

- Genetic algorithms
  - Fitness derived from technique utilization as a proxy for the promised utility (frequency & correlation)
  - Roulette wheel selection & tournament selection
  - Uniform crossover, one point crossover, two-point crossover

- Neural network
  - Generative adversarial network
Evaluation

- Walk forward validation (1 year ahead)

- Test dataset consisting of historic attacks from since 2020

- F-Score

- Baseline
  - „Simulation“ – extrapolation based on current observations
Conclusion

- AFP is an **automated attack predictor** able to **forecast** new malware developments.

- Showed and validated the predictive power based on walk forward validation with a **time horizon of one year**.

- Predictions are not exact rather, **real software deviates slightly from most predictions**.

- AFP increases cyber security maturity and cyber situational awareness through its high predictive capability.

- The results of AFP can be used to prepare proactively for future attacks and improving investment decisions/research spending of defenders, develop security measures **before they were observed in the wild**.

- AFP suffers from data quality and low data availability.
Thank you for your attention
References

