
# OWASP Stammtisch Hannover

## Angriffsgraphen für Threat Modeling und Adversary Emulation

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# Agenda

1. Whoami and Motivation
2. Background
3. System and Graph Design
4. Summary
5. Q&A and Discussion

# Whoami and Motivation

# whoami

- Currently: Senior Expert Penetration Testing
- Previously: Senior Expert Forensics
- 10 years of experience in infosec in critical infrastructures
- I like energy – mainly electricity on all voltage levels
- "Squirrels are more likely to cause power outages than hackers"
- I am not an engineer or developer

**Disclaimer:**
This presentation is a result from personal research and interest.
It is in no way related to or endorsed by my employer.
Each topic of this talk deserves a multi-hour deep dive.

# Motivation

Ukraine Power Outages
2015 & 2016

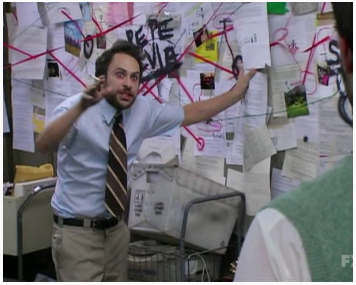
Petrochemical Plant
TRISIS Incident 2017

1. **Advanced adversaries (APT)** pose a risk to ICS environments
2. Defenders need to **prevent, detect and react** to incidents, based on indicators (IOC) and behavior (TTP)
3. Defenders need **exercises** (ideally under realistic circumstances)
4. New **"artificial" adversaries** are required for effective training
5. Adversaries must be **emulated/simulated**

# Background

# Three Core Concepts

Threat Modeling



Attack Graphs

Adversary Emulation

# Threat Modeling

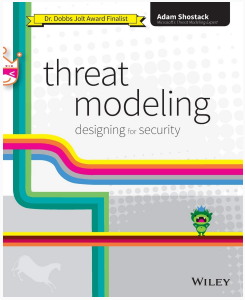
# Threat Modeling

- "All models are wrong, but some are useful." – George Box
  (but we need models for understanding, common language and see similiarities)

- Interdisciplinary approach
- No one-size-fits-all – know your audience/targets
- Centricity: Attacker vs. Asset vs. Software
- Should start as early as possible – explicit and implicit
- No fire-and-forget – it is a continous effort along the whole product lifecycle
  (yes, also in "agile")

# Threat Modeling - Key Questions

- Must read:
  Adam Shostack – "Threat Modeling: Designing for Security"




- What are we working on?
- What can go wrong?
- What are we going to do about it?
- Did we do a good job?

`https://wiki.owasp.org/index.php/OWASP_Threat_Model_Project`

# STRIDE - a mnemonic for threat modeling

S-T-R-I-D-E by Garg/Kohnfelder
https://www.microsoft.com/security/blog/2009/08/27/the-threats-to-our-products/

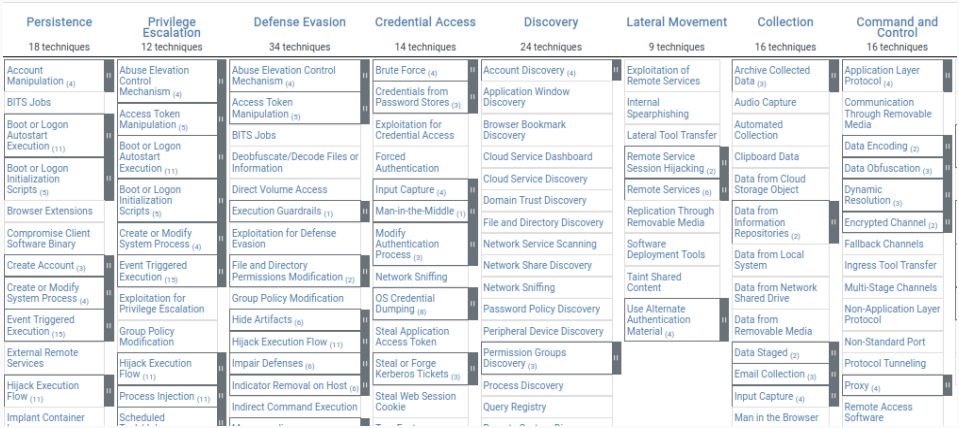
- Spoofing
- Tampering
- Repudiation
- Information Disclosure
- Denial-of-Service
- Elevation-of-Privilege

other methodologies are LINNDUN, hTMM, PASTA, CIA, and many many more
(https://insights.sei.cmu.edu/blog/threat-modeling-12-available-methods/)

# Cyber-Kill-Chain


Originally introduced by Hutchins et al. from Lockheed Martin in 2011

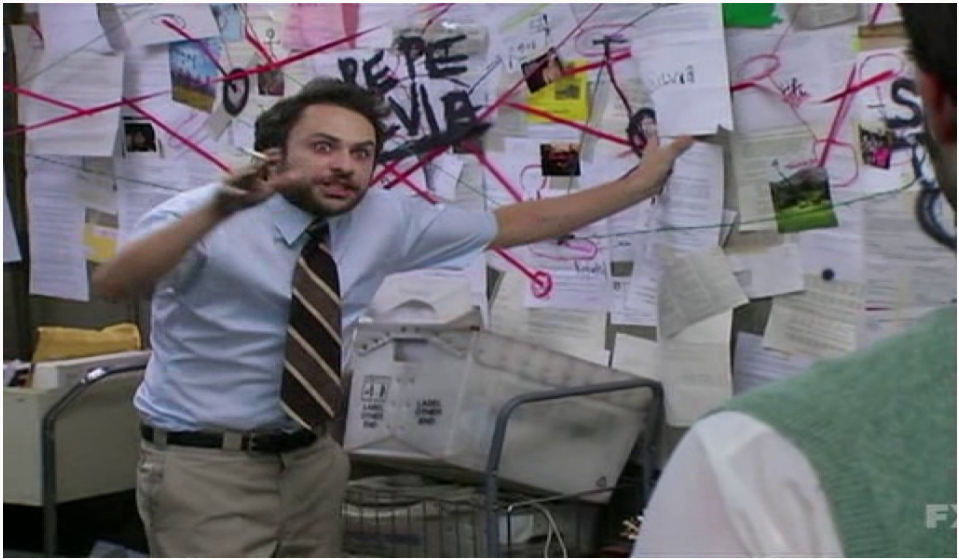
# MITRE ATT&CK



| Persistence | Privilege Escalation | Defense Evasion | Credential Access | Discovery | Lateral Movement | Collection | Command and Control |
|---|---|---|---|---|---|---|---|
| 18 techniques | 12 techniques | 34 techniques | 14 techniques | 24 techniques | 9 techniques | 16 techniques | 16 techniques |
| Account Manipulation (4) | Abuse Elevation Control Mechanism (4) | Abuse Elevation Control Mechanism (4) | Brute Force (4) | Account Discovery (4) | Exploitation of Remote Services | Archive Collected Data (3) | Application Layer Protocol (4) |
| BITS Jobs | Access Token Manipulation (5) | Access Token Manipulation (5) | Credentials from Password Stores (3) | Application Window Discovery | Internal Spearphishing | Audio Capture | Communication Through Removable Media |
| Boot or Logon Autostart Execution (11) | Boot or Logon Autostart Execution (11) | BITS Jobs | Exploitation for Credential Access | Browser Bookmark Discovery | Lateral Tool Transfer | Automated Collection | Data Encoding (2) |
| Boot or Logon Initialization Scripts (5) | Boot or Logon Initialization Scripts (5) | Deobfuscate/Decode Files or Information | Forced Authentication | Cloud Service Dashboard | Remote Service Session Hijacking (2) | Clipboard Data | Data Obfuscation (3) |
| Browser Extensions | Create or Modify System Process (4) | Direct Volume Access | Input Capture (4) | Cloud Service Discovery | Remote Services (6) | Data from Cloud Storage Object | Dynamic Resolution (3) |
| Compromise Client Software Binary | Event Triggered Execution (15) | Execution Guardrails (1) | Man-in-the-Middle (1) | Domain Trust Discovery | Replication Through Removable Media | Data from Information Repositories (2) | Encrypted Channel (2) |
| Create Account (3) | Exploitation for Privilege Escalation | Exploitation for Defense Evasion | Modify Authentication Process (3) | File and Directory Discovery | Software Deployment Tools | Data from Local System | Fallback Channels |
| Create or Modify System Process (4) | Group Policy Modification | File and Directory Permissions Modification (2) | Network Sniffing | Network Service Scanning | Taint Shared Content | Data from Network Shared Drive | Ingress Tool Transfer |
| Event Triggered Execution (15) | Hijack Execution Flow (11) | Group Policy Modification | OS Credential Dumping (8) | Network Share Discovery | Use Alternate Authentication Material (4) | Data from Removable Media | Multi-Stage Channels |
| External Remote Services | Process Injection (11) | Hide Artifacts (6) | Steal Application Access Token | Network Sniffing | | Data Staged (2) | Non-Application Layer Protocol |
| Hijack Execution Flow (11) | Scheduled | Hijack Execution Flow (11) | Steal or Forge Kerberos Tickets (3) | Password Policy Discovery | | Email Collection (3) | Non-Standard Port |
| Implant Container | | Impair Defenses (6) | Steal Web Session Cookie | Peripheral Device Discovery | | Input Capture (4) | Protocol Tunneling |
| | | Indicator Removal on Host (6) | | Permission Groups Discovery (3) | | Man in the Browser | Proxy (4) |
| | | Indirect Command Execution | | Process Discovery | | | Remote Access Software |
| | | | | Query Registry | | | |

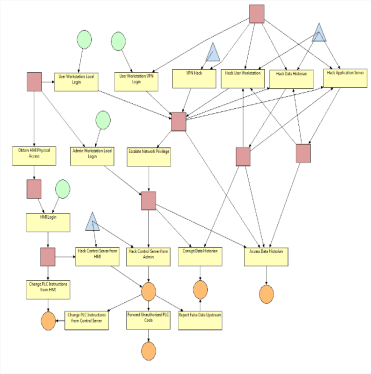
Excerpt from `https://attack.mitre.org/`

# Attack Graphs



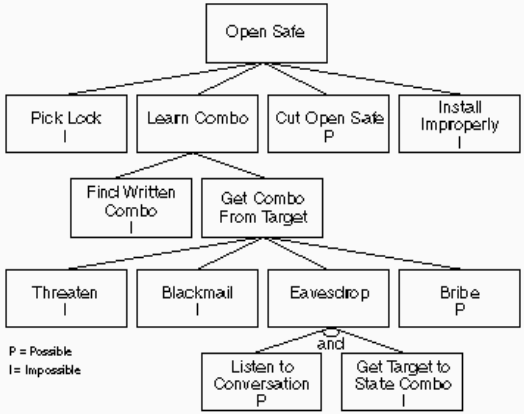
# Attack Graphs

- Schneier, Kordy, LeMay, Ekstedt and many more
- Started with fault tree analysis
- Attacks can be modeled intuitively with graphs/trees
- Focus mainly on assets less on the actions
- Used for modeling defenses, attack chains and critical paths
- Automated generation has been shown to be possible



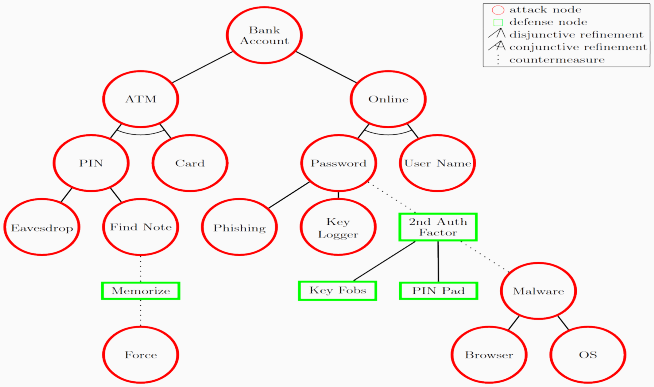

(LeMay et al., Attack Execution Graphs, 2011)

# Early Forms of Attack Graphs




Attack Tree
(Schneier, Dr. Dobb's Journal, 1999)

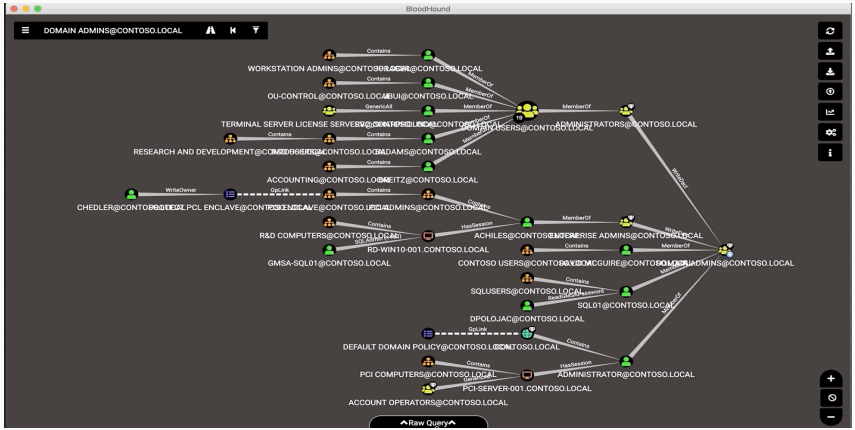
# Attack-Defense-Trees




Attack-Defense-Tree

(Kordy et al., Foundations of attack–defense trees, 2010)

# Bloodhound Attack Tree



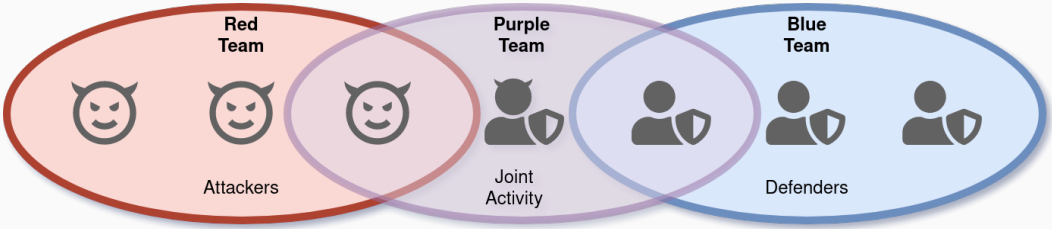

Bloodhound Active Directory

`https://bloodhound.readthedocs.io/en/latest/index.html`

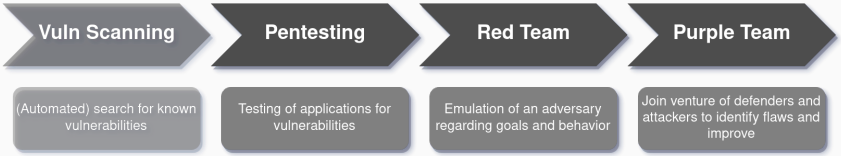
# Adversary Emulation

# Different Teams

Who is involved in adversary emulation and simulation?



# Adversary Emulation and Simulation



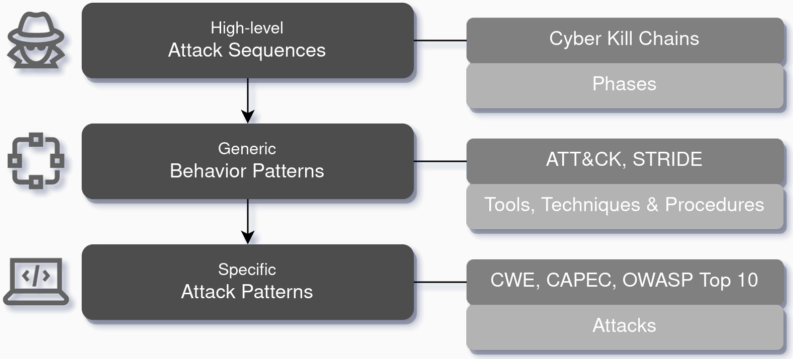

- Offensive Security for Defensive Activities
- Reproduction of adversarial behavior (TTP) to train/assess/improve defender's capabilities
- Purple teaming is highest maturity for offensive security activities
- Adversary Emulation vs. Adversary Simulation

# Adversary Behavior Execution

- "Exercises" / Human Activities
  1. Red and Purple Teaming
  2. Table-Top Exercises
- Automated execution / Machine Activities
  1. Simulation
  2. Machine Learning

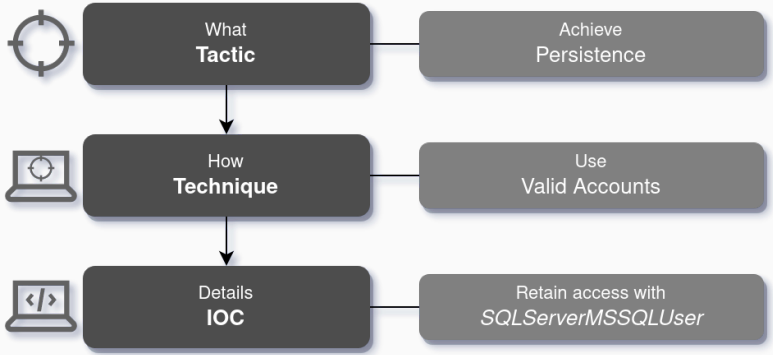
# Classification of Attack Models

Which **level of detail required** for designing attack graphs for adversary behavior execution?



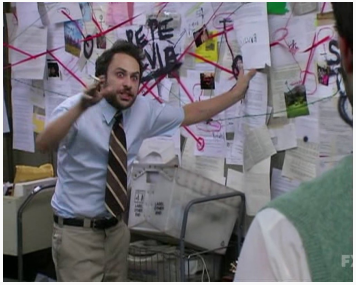
# From high level goals to actions

For an effective adversary behavior execution low level activities have to be developed.



# Three Core Concepts

Threat Modeling

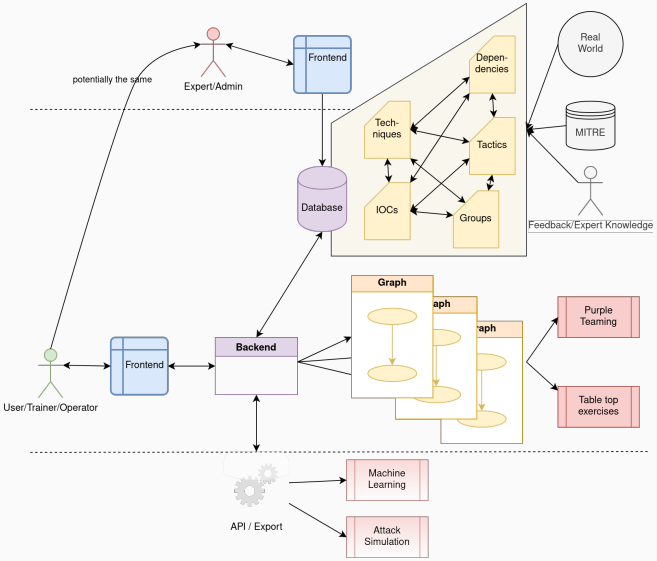


Attack Graphs

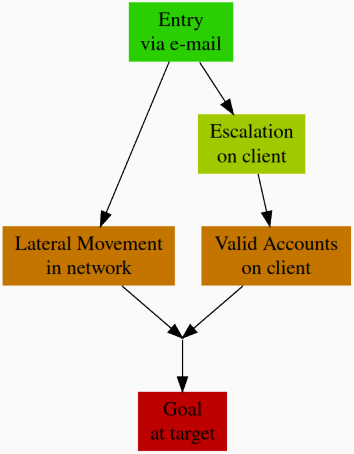
Adversary Emulation

# System and Graph Design

# System Design



# Graph Design




1. Graphs
   - Set of nodes and edges describing the adversary profile
   - Focus on emulation/simulation of attack Techniques
   - Sequential along MITRE Tactics (the “what”)
2. Nodes
   - Instantiated Techniques as individual hacking steps (the “how”)
   - Associated with targets and indicators
3. Edges
   - Technique’s results and status

# Example Generated Graph


Shallow Cyber 1067.BO

# Example Generated Graph

# Live Demo

# Summary

# Summary and Future Work

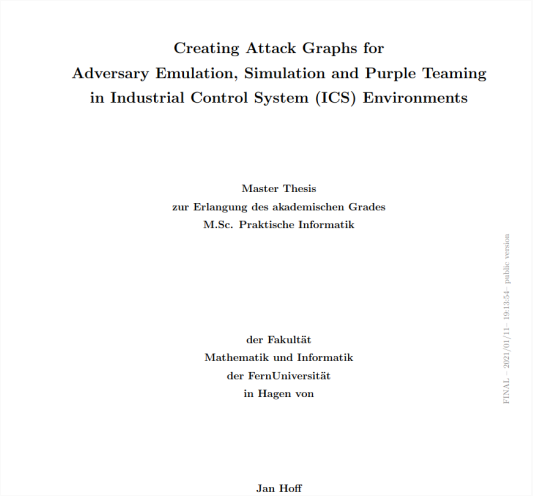
- Conclusion
  - Threat modeling is a powerful methodology to include security early on
  - Automated attack graph generation for adversary behavior execution is possible
  - Experts confirm viability of approach and prototype
- Future work
  - Detailed node generation (IOC level) and integration with formal models/languages
  - Machine learning use cases and Bayesian networks
  - Defender profile mapping with threat and defense modeling

# Q&A and Discussion

# Further Reading

Get the full text and source of the application from:
`https://www.pull-the-plug.net/thesis/`

Get in touch at:
`https://www.linkedin.com/in/jahoff/`


Creating Attack Graphs for
Adversary Emulation, Simulation and Purple Teaming
in Industrial Control System (ICS) Environments

Master Thesis
zur Erlangung des akademischen Grades
M.Sc. Praktische Informatik

der Fakultät
Mathematik und Informatik
der FernUniversität
in Hagen von

Jan Hoff

FINAL - 2021/01/11 - 19:13:54 - public version

# Thank you

# References and Credits

1. Latex beamer template: `https://github.com/matze/mtheme`
2. "Ukraine" power lines: `https://unsplash.com/`
3. Petro Rabigh plant: https://www.meed.com/petro-rabigh-[...]-from-co-owners
4. All other photos: `https://unsplash.com/` or common memes
5. Further references and a complete bibliography can be found at: `https://www.pull-the-plug.net/thesis/`