Advanced Privilege Escalation Prevention System in Windows

01. Introduction

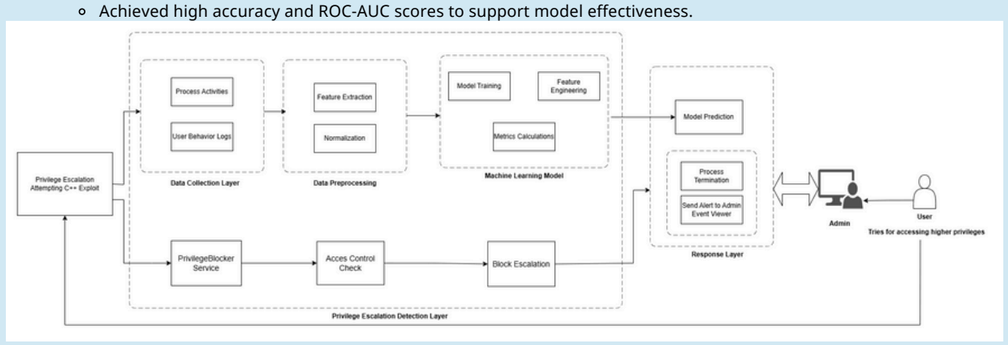
In the evolving landscape of cybersecurity threats, privilege escalation remains one of the most critical attack vectors. Once attackers gain initial access to a system, they often attempt to elevate their privileges to gain control over sensitive resources, execute administrative tasks, or maintain persistence. This project introduces "PrivilegeBlocker", a lightweight yet effective Windows-based detection and prevention system designed to monitor, detect, and stop privilege escalation attempts in real time. Unlike traditional antivirus or endpoint protection software, PrivilegeBlocker focuses specifically on process-level monitoring, token analysis, and security log auditing to identify anomalous behavior. To reinforce the system's intelligence, a machine learning model was externally developed to simulate detection capabilities, training on synthetic features that characterize malicious versus normal process behavior. This hybrid approach of system-level monitoring and intelligent detection helps demonstrate a proactive defense mechanism against privilege abuse.

02. Objective

Simulate a privilege escalation attack in a windows environment. Design and implement a prevention system (PrivilegeBlocker) that monitors and blocks such attacks. Include a machine learning model to analyze behavior and improve detection accuracy.

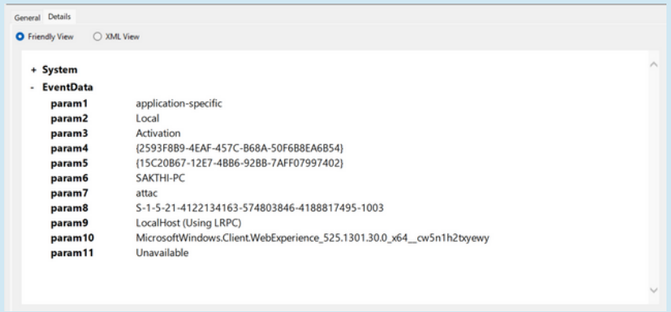
03. Methods

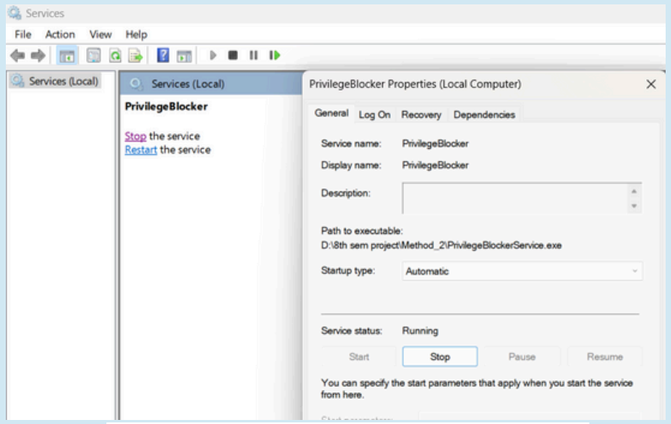
- Attack Simulation (Privilege Escalation)
  - Developed a custom C++ exploit that attempts to gain administrative privileges from a standard user context.
  - The exploit simulates real-world token manipulation techniques often used in privilege escalation attacks.
  - Consequences of the simulated attack are demonstrated to highlight system vulnerabilities.
- Detection Mechanism
  - A Windows Service (PrivilegeBlocker) written in C# runs in the background.
  - It monitors:
    - New Process Creation
    - Parent-child process chains
    - User Tokens & Privilege levels
  - Suspicious or unauthorized privilege changes are flagged in real-time.
- Prevention System
  - The system kills malicious processes attempting escalation based on detection heuristics.
  - Uses event log correlation and process inspection to identify privilege abuse patterns.
  - Sends alerts or notifications when a potential escalation is blocked.
- Machine Learning Integration (External)
  - Built a stacked ensemble ML model (XGBoost + Random Forest + SVM) to simulate detection accuracy.
  - Trained on synthetically generated behavioral features of normal vs. escalated processes.
  - Used SMOTE for class balance and Optuna for hyperparameter tuning.
  - Achieved high accuracy and ROC-AUC scores to support model effectiveness.

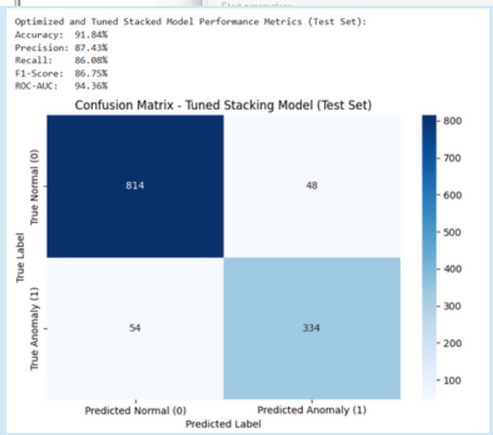


04. Results/Findings

- Successfully simulated privilege escalation using custom C++ code.
- Deployed PrivilegeBlocker – a Windows Service that detects and blocks unauthorized privilege elevation attempts.
- Designed and trained a machine learning model using Random Forest, XGBoost & SVM to predict malicious privilege escalation behavior with high accuracy of 91.42%
- System logs suspicious behavior and alerts user/admin via Event Viewer.
- Demonstrated effectiveness in real Windows environment (not VM)







05. Conclusion

- This project successfully developed a Windows-based Privilege Escalation Detection and Prevention System that addresses one of the most critical threats in cybersecurity: unauthorized privilege elevation. By simulating real-world attacks through custom C++ code and integrating a lightweight, proactive service (PrivilegeBlocker), the system effectively monitored and intercepted suspicious activity in real time.
- The inclusion of an externally trained Machine Learning model enhanced detection accuracy and supported behavior-based analysis of system processes. This dual-mode detection—combining rule-based monitoring and ML-based prediction—ensured higher reliability in identifying and blocking attacks.
- Overall, the solution demonstrated practical feasibility, strong performance, and adaptability across Windows environments without relying on virtual machines or external admin tools like Mimikatz. It provides a valuable contribution toward building self-defending endpoints and strengthens awareness of OS-level security mechanisms.

06. References

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