Detection of Malicious Code

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Problem

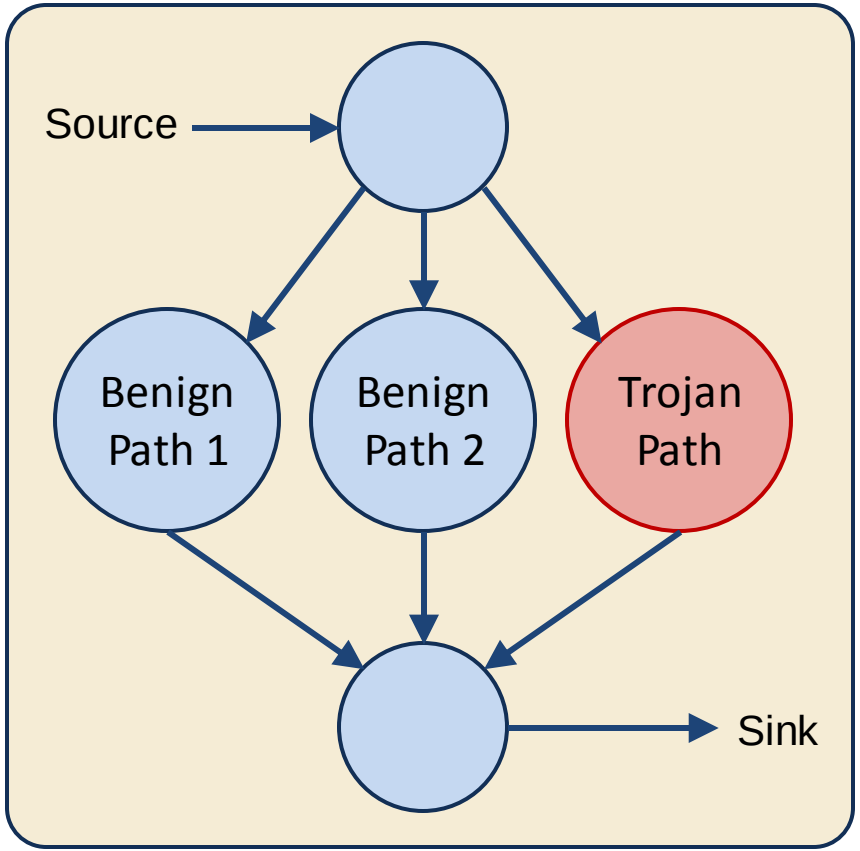
- DoD uses much software produced by various supply chains.
- These supply chains can be compromised by an adversary:
  - Network intrusion
  - Insider threat
- Failing to detect malicious code can be very costly.
- Example: SolarWinds incident of 2020.
- Detection is currently impractical.

Our solution

- We will design a static analysis to detect two types of malicious code:
  - Exfiltration of potentially sensitive information (e.g., keyloggers)
  - Calling a potentially sensitive system API call (e.g., writing to a file, starting a new process, etc.) in response to a potentially questionable trigger (e.g., on a specific date, in response to incoming network packets, etc.)
    - E.g., Remote-Access Trojan
- We will use ***information flow*** techniques, as well as other static analysis.
- Our tool will also attempt to find *witness traces* detailing the flows.
- E.g., for the malware injected in the SolarWinds Orion code, we would find:
  - Execution trace where attacker launches an arbitrary process
  - Execution trace where attacker writes arbitrary data to arbitrary files
  - Etc.

Information Flow Analysis

- Interprocedural, Finite, Distributive Subset (IFDS) algorithm
  - has successful track record, e.g., finding malicious flows of information in Android apps.
  - Sources: designated system API calls that return potentially sensitive information.
  - Sinks: designated system API calls that can be used to exfiltrate data to an attacker.
- Limitation: conflates together all flows from a given source to a given sink.
- So, a malicious flow can be 'hidden' by a benign flow.
- Our idea: Separate flows according to which parts of the code are exercised in propagating the flow.



Technical approach

- We will implement an IFDS-based analysis with an enhancement to prevent malicious flows from being masked by legit flows.
- For each LLVM IR instruction or basic block:
  - If there is a flow involving this code, ensure we generate at least one witness trace for it.
- This identifies flows in malicious code separately from flows in legit code.
- Identify restrictions on what data an attacker can pass to sensitive sinks (e.g., reading files restricted to only a single folder).
- A human analyst examines the flows to determine whether they are malicious.
  - Reduce false alarms by filtering out alarms about potentially sensitive operations that the user indicates would be expected of the program being analyzed.
  - Develop other techniques to prioritize alerts and reduce false positives.

Technical questions

1. Which platform(s) are of greatest interested? (E.g., Java, C/C++ code for x86 Windows, code for embedded systems, etc.)
2. Are you mostly interested in analyzing binaries, or is analysis of code source of interest too?
   - For C/C++ source code, we would plan to do the analysis at the LLVM IR level.
   - For binaries, we can do analysis at the LLVM IR level using a binary-to-LLVM lifter, but accuracy might be too low.
3. Are any particular system API calls (or categories of API calls, or general characteristics) of greatest interest?
   - What about direct I/O without using system calls?
4. Do you have any suggestions for malicious and benign benchmarks?
   - github.com/ytisf/theZoo
   - Examples for types of malicious code (e.g., keyloggers, timebombs) that you're most interested in?

Our transition goal

- Our goal is to develop a tool that provides enough benefit for it to be integrated into operational tools/processes.
- Question: What would be needed of the tool for it to provide this level of benefit?

Requested feedback for preliminary version of tool

- We aim to have a preliminary version of our tool ready around July or August.
- Would you be available to try running the tool and give us feedback?
  - Would you be able to run the tool on representative code that you might be unable to share with us?
  - If running on software that you cannot share with us, can you share basic summary stats (e.g., numbers of various types of flows, any errors/crashes from the tool, analysis time)?
  - What is the useful about the tool?
  - What needs to be improved for the tool to be provide enough benefit to be used in operational practice?
- In year 2 of this two-year project, we would like to engage more closely with you, aiming to improve the tool so that it can provide real benefit in operational use.

Plans for further meetings

- We plan to update you regularly by email on our progress.
- We'd also like to meet occasionally as the tool becomes more fleshed out, to ensure that we're still on track to produce a tool that would be useful to you.