CodeXt:
Automatic Extraction of Obfuscated Attack Code from Memory Dump

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Where Innovation Is Tradition

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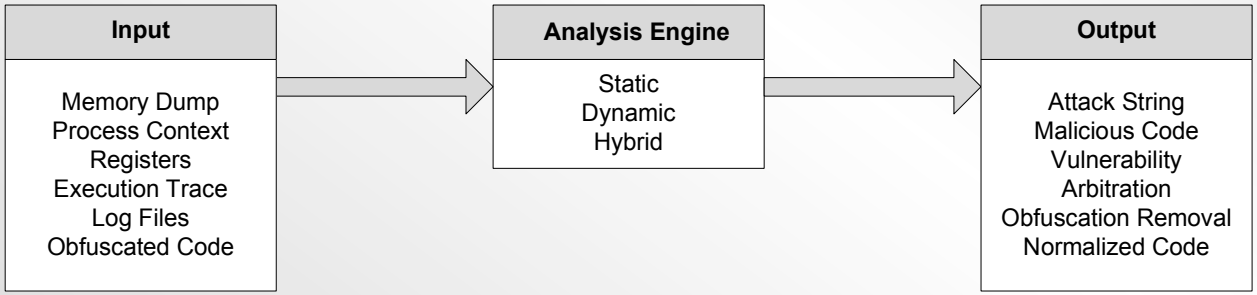
Problem

- Need to automate upon detection in memory
  - Avoid substantial manual effort
    - Automatically recover malcode
    - Extract/unpack/recover attack code
  - Memory dump, transient artifacts



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Existing Tools

- Only work with known boundaries
  - Typically designed for full binaries
    - e.g., PE files
  - Things get nasty without given boundaries
    - Or are arbitrary byte streams
- Don't generically handle
  - Malformed, Misaligned
  - Obfuscated, Armored

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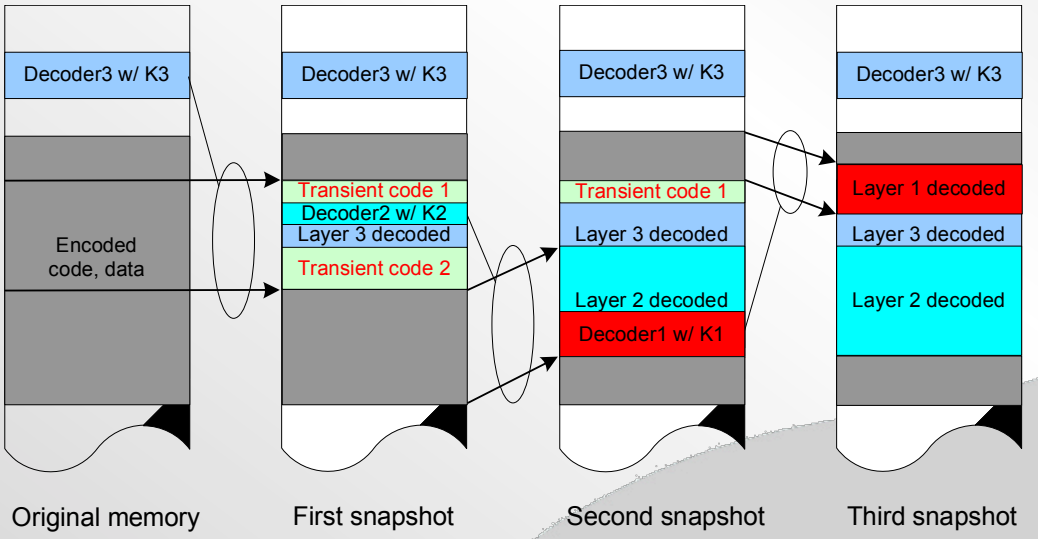
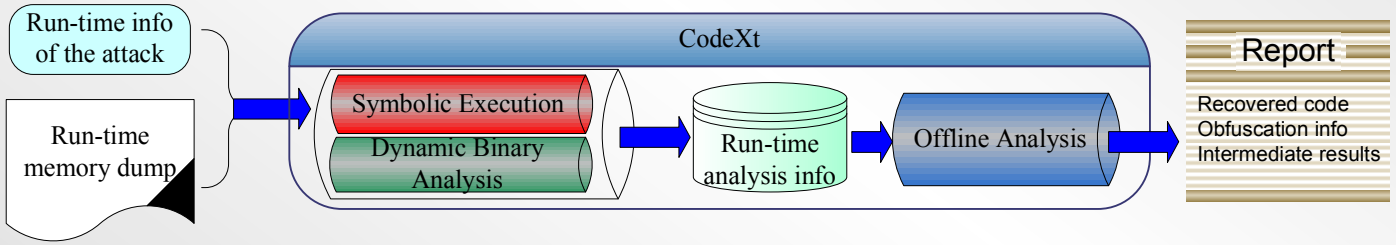
Solution: CodeXt

- Discovers executable code within memory dump
  - Upon realtime detection
- Extracts packed or obfuscated malcode
  - First to generically handle Incremental and Shikata-ga-nai



Solution: CodeXt

- Framework built upon S2E
  - Selective means QEMU vs KLEE (LLVM)
  - Decision made per basic block



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CodeXt Output

- Instruction Trace of executed instructions
  - Grouping of fragments into chunks
  - Reveals original and unpacked malcode
  - Assisted by a translation trace
- Data Trace of memory writes
  - Intelligent memory update clustering
  - Multi-layer snapshots
- Call Trace of system calls
  - With CPU context

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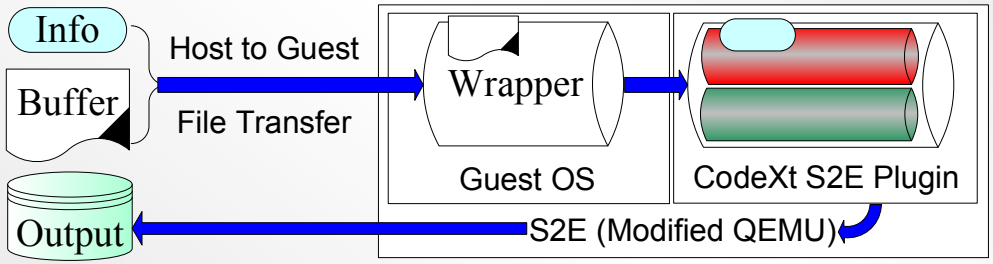
Problems + Challenges + Solutions

Handling Byte Streams

- S2E expects well structured binaries
  - We wrap the binary for execution



- S2E uses basic block granularity
  - Our modified QEMU translation returns more info
  - We leverage translation and execution hooks to verify

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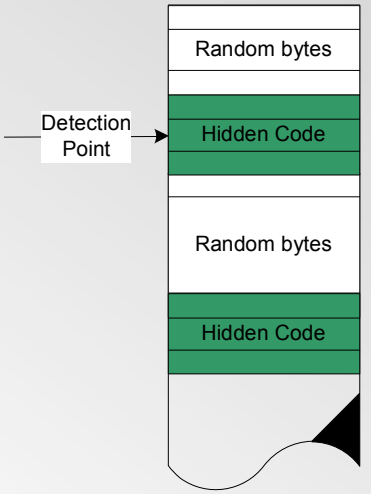
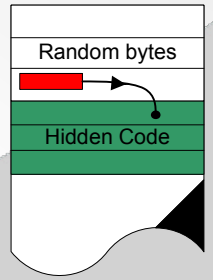
Recognizing Code

- Avoiding the Halting Problem
  - No infinite loops
  - Caps on executed instructions
    - Different types: target, non-target, system
- False cognates
  - Illegal first instructions
  - False jumps into suffix
- Many substrings
  - Matched code fragment: ends on system call, EAX within range





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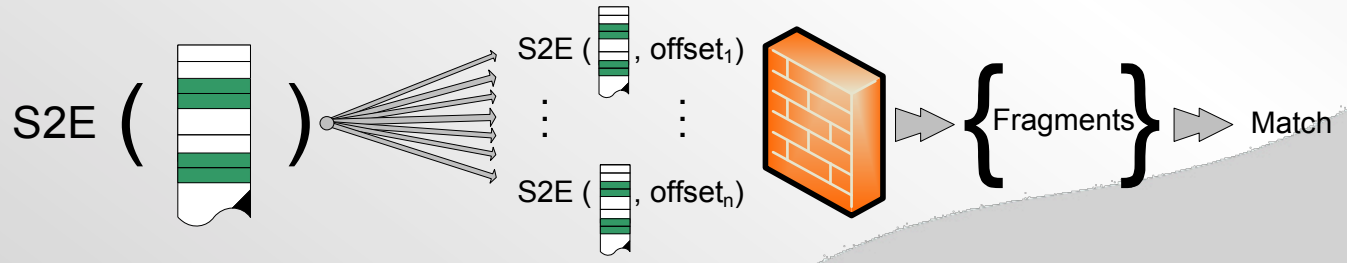
Dealing with Code Fragments

- Fragmentation
  - Clustering into Chunks, adjacency, execution trace
- Density
  - Usage: Executed/Range
  - Overlay: Unique executed/Range over snapshots
- Enclosure
  - Continuous executable bytes adjacent to end



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Defeating Obfuscation

- FPU instructions, fnstenv
  - Added small change to QEMU to comply
- Intra-basic block self-modification
  - We know address range of each translated block
  - During execution we track writes
  - If any write is to same block we retranslate block
- Emulator detection
  - Tested for a set of obscure instructions used as canaries

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Results

Experiments

- Hidden code search
  - 1KB to 100KB buffers, 40B to 80B shellcodes
  - Filled with either null, live-capture, or random bytes
  - Varied assistance data: EIP, EAX, both, neither
- Accuracy
  - De-obfuscation, Anti-emulation detection
  - Various packers mentioned in previous research
  - In-shop: Junk code insertion, Ranged xor, Incremental
- Symbolic Branching

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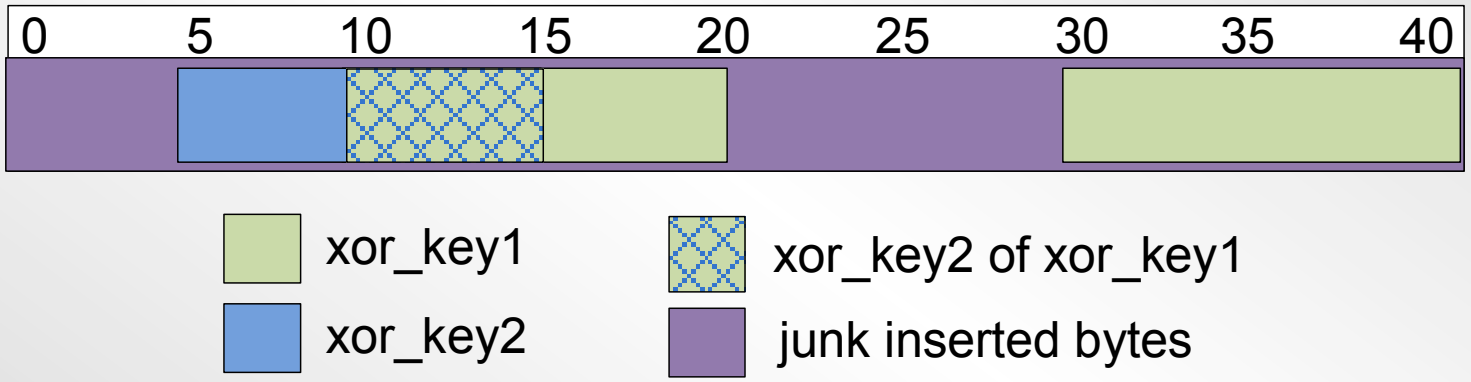
Multi-Layered Encoders



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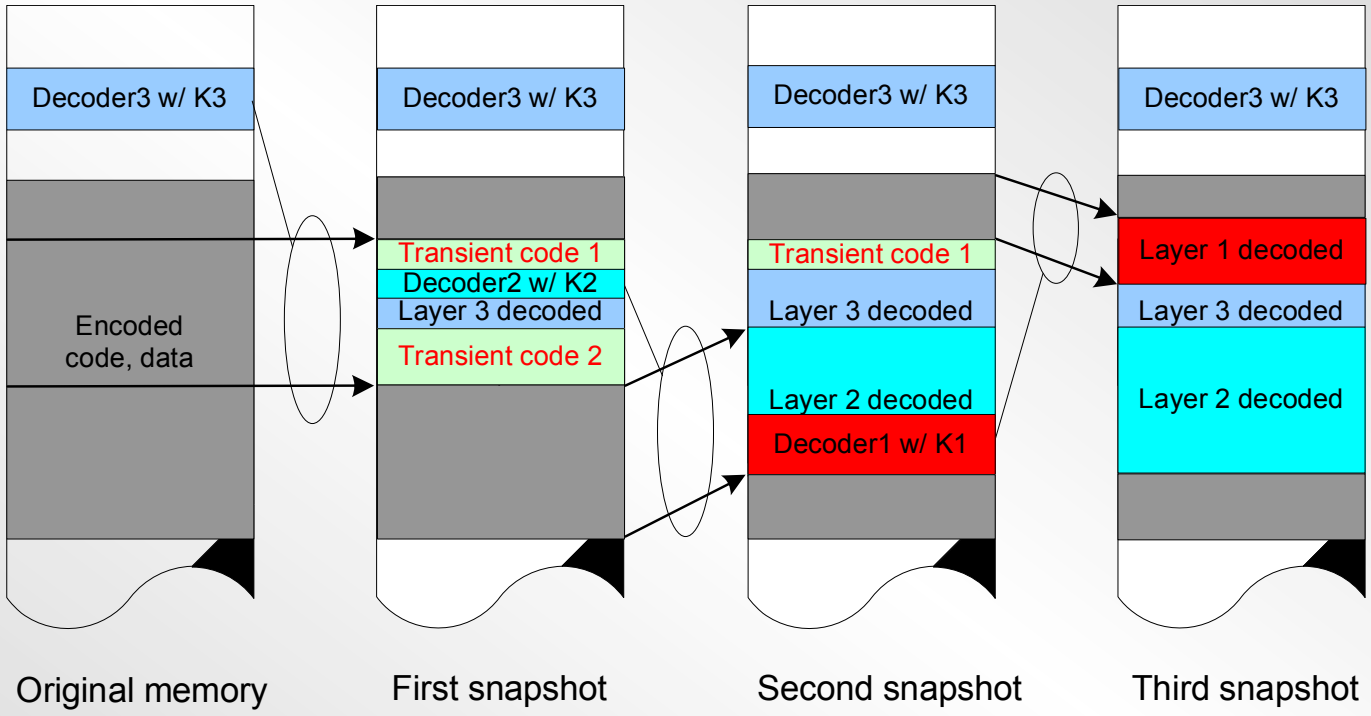
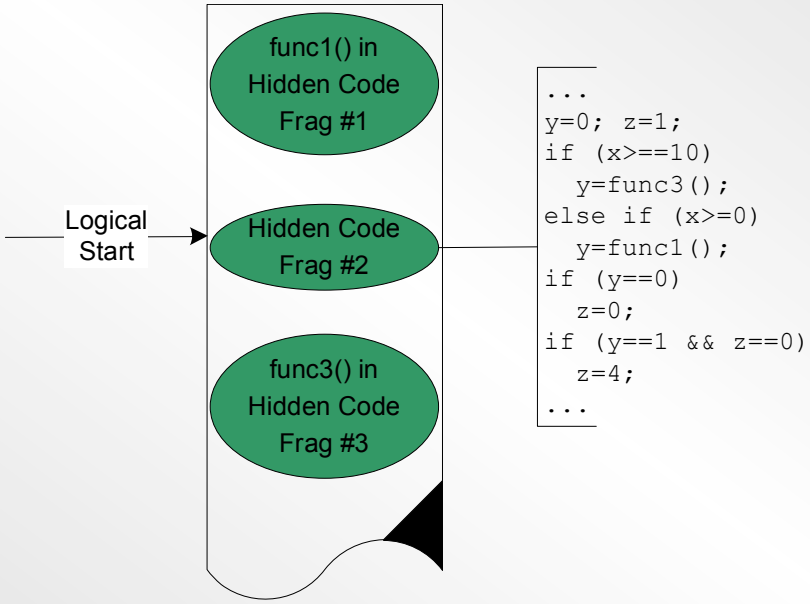
Incremental Encoder



Symbolic Conditionals



Conclusion

- Emulation is heavy-weight, but
  - Accurate and enables anti-anti-sandbox techniques
  - OS independent
- Symbolic analysis engine opens avenues
  - Taint propagation and analysis
  - Fuller branch exploration and pruning heuristics
- CodeXt
  - Accurately pinpoints and models even highly obfuscated code in adverse conditions.

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Current/Future Development

- Full binary (ELF/PE) support
  - Modeling unmodified executables
  - Without source code
- Data and code based taint analysis
  - Can mark any input
    - e.g., all network socket reads
  - Follow not only by data, but instruction influence

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Thank you for your time

- Any questions?

Post-talk, please feel free to contact us

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