

Encoded Pointer Memory Analysis Pattern

Intent

To recognize situations where a pointer stored in memory is not directly usable: its value must be interpreted or transformed before it can be resolved to a valid code or data address.

Context

[Stack Trace](#), [Execution Residue](#), [Context Pointer](#), [Historical Information](#)

Common environments:

- ◉ Tagged pointers
- ◉ ARM64 pointer authentication (PAC)
- ◉ Top-Byte-Ignore tagging (AArch64)
- ◉ ASLR and relocations that have not yet been applied in the captured memory
- ◉ Managed space compressed and metadata-embedded GC pointers
- ◉ Objective-C and Swift tagged ISA pointers
- ◉ Sanitizers or checking runtimes that add metadata bits

Problem

A pointer in the dump visually appears to be an address, but fails to resolve using normal symbolic or spatial checks; dereferencing its raw value yields an incorrect memory address or a memory error.

Forces

- ◉ Performance/security constraints favor encoded pointer formats
- ◉ Debugger views often show raw stack/heap
- ◉ Encoding schemes vary by platform and compiler
- ◉ Hardware PAC may prevent guessing the correct pointer form without a proper decode context

Symptoms

- ◉ Pointer value not inside any loaded module or valid virtual address range
- ◉ Symbol resolution differs
- ◉ Adjacent stack slots look pointer-like, but this one does not
- ◉ Backwards disassembly shows an incorrect frame

Resolution Strategies

- ◉ Decode PAC
- ◉ Canonicalize upper bits
- ◉ Strip tags
- ◉ Expand bits
- ◉ Apply relocation deltas
- ◉ Mask metadata

Resulting Context

After correct interpretation, the pointer becomes:

- ◉ Resolvable to a target symbol
- ◉ Walkable for call-stack reconstruction
- ◉ Safe for dereferencing in analysis context
- ◉ Enables further analysis

Examples

[Software Diagnostics Library](#)

Related Patterns

[Invalid Pointer](#)