Fine-Grained Load-Time Randomization of ELF binaries

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- **70%** of compiled code **vulnerabilities** are due to **memory safety** issues.
- Return-oriented programming (ROP) is a class of code reuse attacks that attackers are widely using.
- **Fine grained code randomization** is a **solution** to mitigate this type of code reuse attacks.

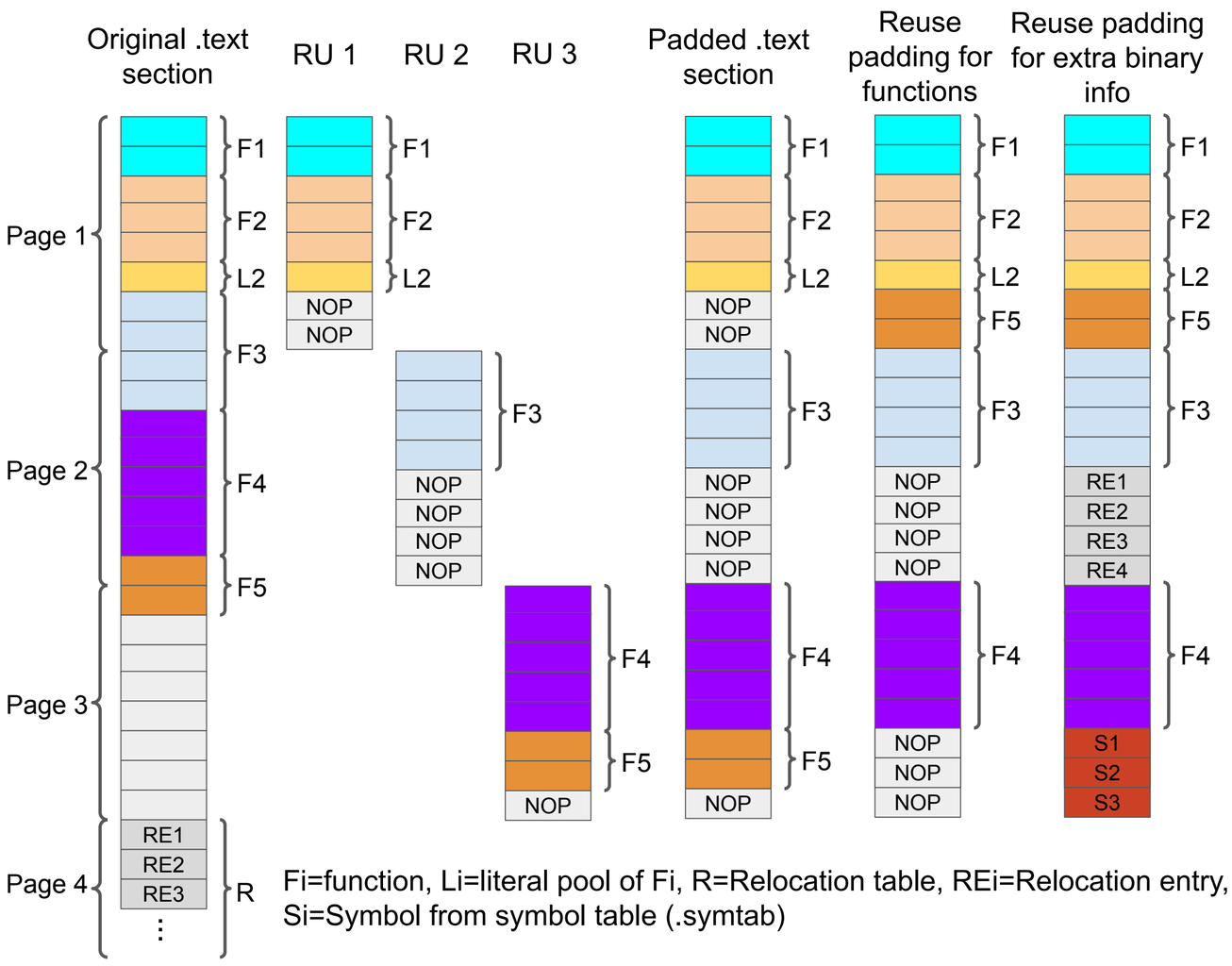
Randomization requirements

- Randomization per execution to be secure against brute forcing
- Randomization at **load time** or later to be secure against static analysis
- **Randomize each page when it is loading into memory** (page fault)
  - Reduce load time overhead
  - Not randomize pages that will not be loaded

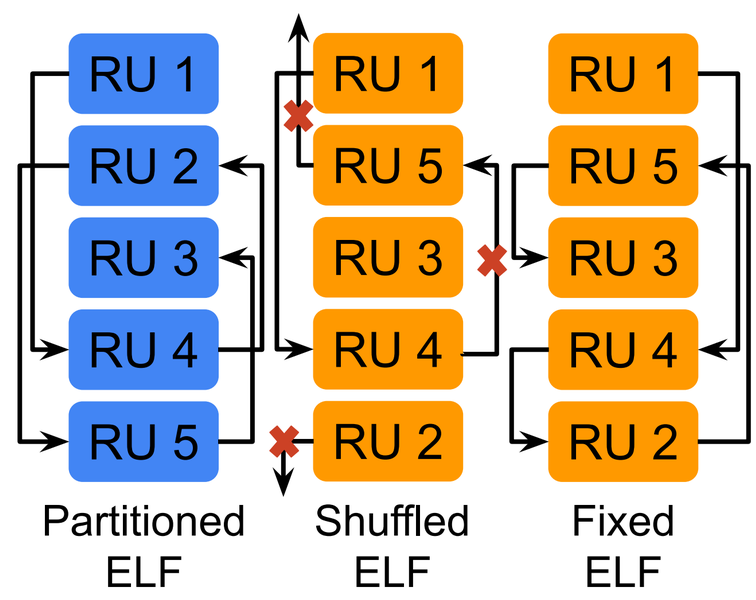
- Exploiting a memory safety vulnerability:
  - Overflow (Mitigated by control-flow integrity and stack canaries)
  - Code injection (Mitigated by W⊕X)
  - Code reuse (Mitigated by ASLR)
  - **Code reuse + information disclosure** (code randomization) (No widely deployed method)

ELF randomization steps

1. **Partition** code section into Randomization units (RU) with configurable size (e.g. page size)
2. **Shuffle** the RUs randomly
3. **Fix** all **addresses** used in the binary (e.g. target in branch instructions)



Fi=function, Li=literal pool of Fi, R=Relocation table, REi=Relocation entry, Si=Symbol from symbol table (.symtab)



Problem

- **Functions** in an RU need to **not cross page boundary** so randomization doesn't break functions

Solution

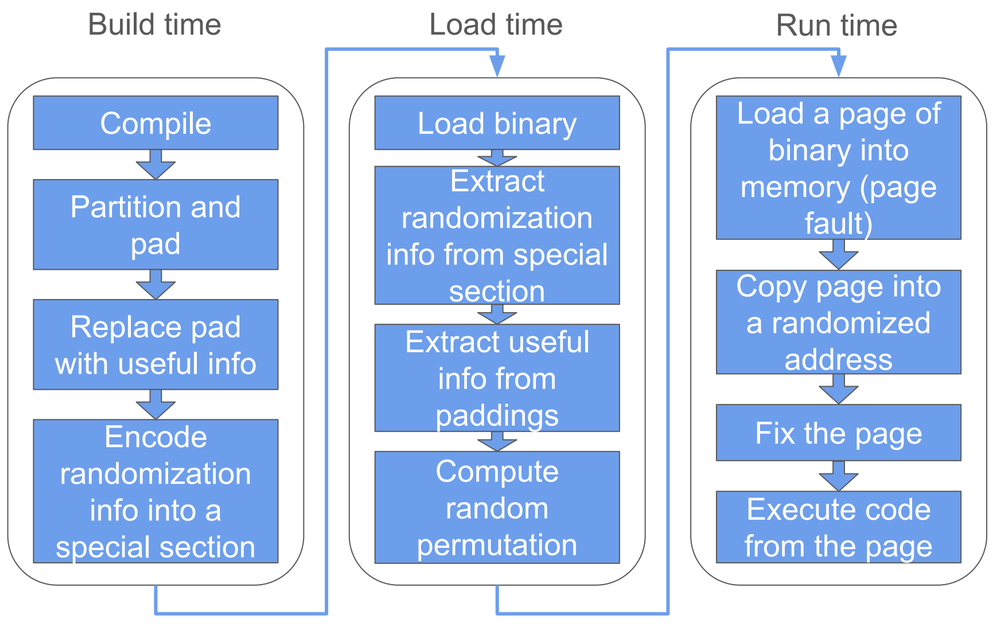
- **Insert padding** after each RU to **make page aligned**

New problem

- Padding at the end of RUs, **expands** the **original binary**

New solution

- **Repurpose paddings** to store randomization data, relocation entries, or RUs.



Conclusion

- **Defense** against **code reuse attacks (ROP)** in presence of **information disclosure**
- **Reduce** the **size** of **randomized binaries**

Future work

- **Randomise** pages in demand on **load time** (modify loader)
- **Compatibility** with **signature** and attestation
- **Compatibility** with **page sharing** in shared libraries

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