NIST INFORMATION TECHNOLOGY LABORATORY

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Bug, Fault, Error, Weakness, or Vulnerability

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Motivation

- Software security vulnerabilities are leveraged to attack cyberspace and critical infrastructure, leading to security failures. When communicating about them, however, even security experts might conflate essential related software concepts.

Objective

- Define software security bug, exploitable error, weakness, and vulnerability; software fault and error; and failure in the context of cybersecurity, and elucidate their causation and propagation.

Software Security Concepts Definitions

Software security bug/fault types relate to distinct phases of software execution with specific operations, the input operands to the operations, and the output results from the operations.

- A software security bug is a code or specification defect (an operation defect) – proper operands over an improper operation.
- A software fault is a name, data, type, address, or size error (an operand error) – improper operands over a proper operation.

  ‘Name’ is about a resolved or bound object, function, data type, or namespace; ‘data’, ‘type’, ‘address’, and ‘size’ are about an object.
- A software error is a result from an operation with a bug or an operation with a faulty operand that can propagate to a new fault.
- A software security exploitable error is an undefined system behavior that results from an operation with a faulty operand.
- A software security weakness is a `(bug, operation, error)`, `(fault, operation, error)`, or a `(fault, operation, exploitable error)` triple; i.e., it is of a bug type – a bug causes an error, or of a fault type – a fault causes an error or an exploitable error.
- A software security vulnerability is a chain of weaknesses that starts with a bug, propagates through errors that become faults, and ends with an exploitable error.

  The bug must be fixed to resolve the vulnerability; fixing a fault will mitigate the vulnerability.
- A security failure is a violation of a system security requirement caused by an adversary attack leveraging an exploitable error.

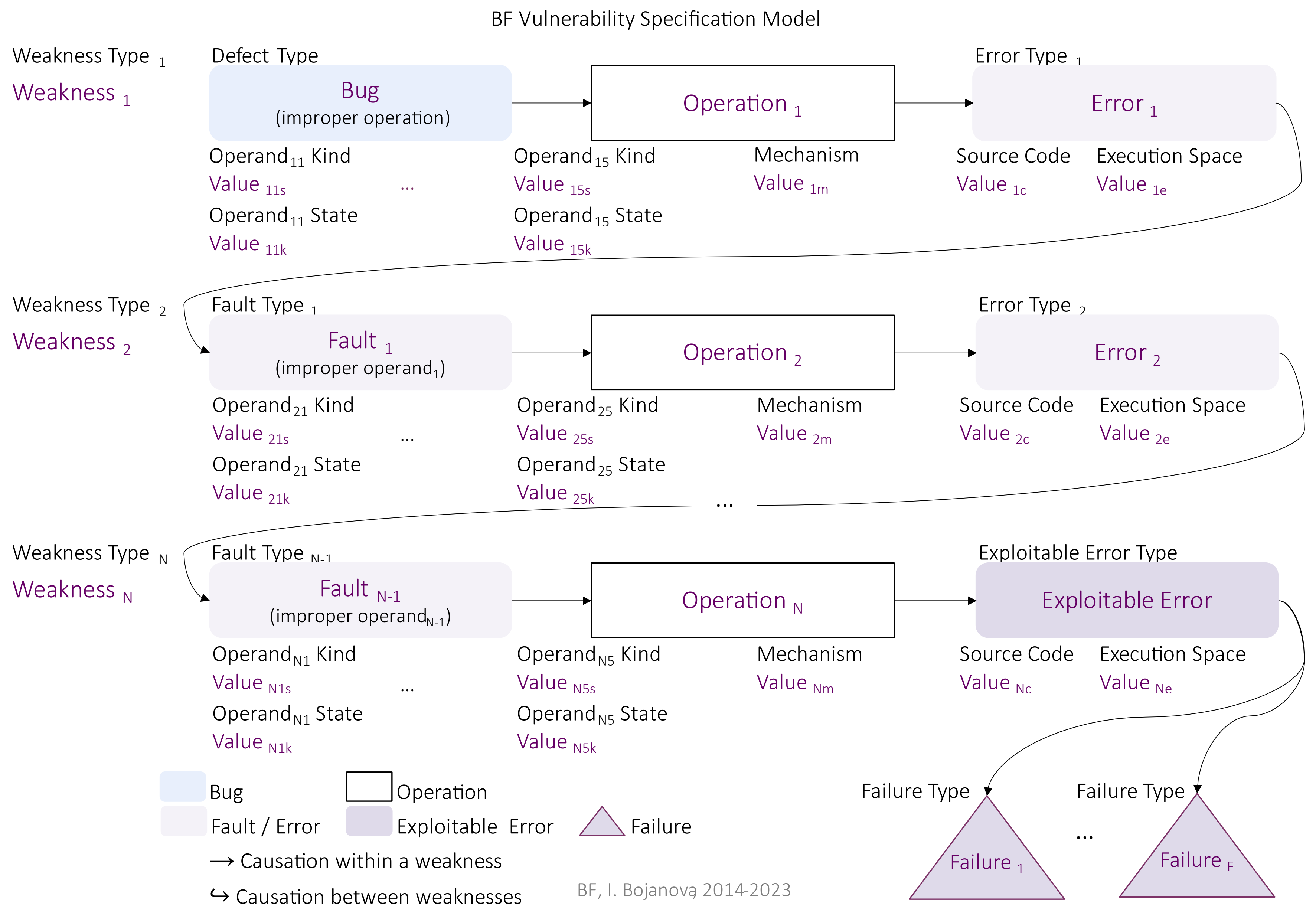
A failure may result in a fault, causing a new vulnerability of only fault type weaknesses. Fixing the bug in the first vulnerability will resolve the chain of vulnerabilities.

Occasionally, for an exploit to be harmful, several vulnerabilities must converge at their exploitable errors. The bug in at least one of the chains must be fixed to avoid the failure.

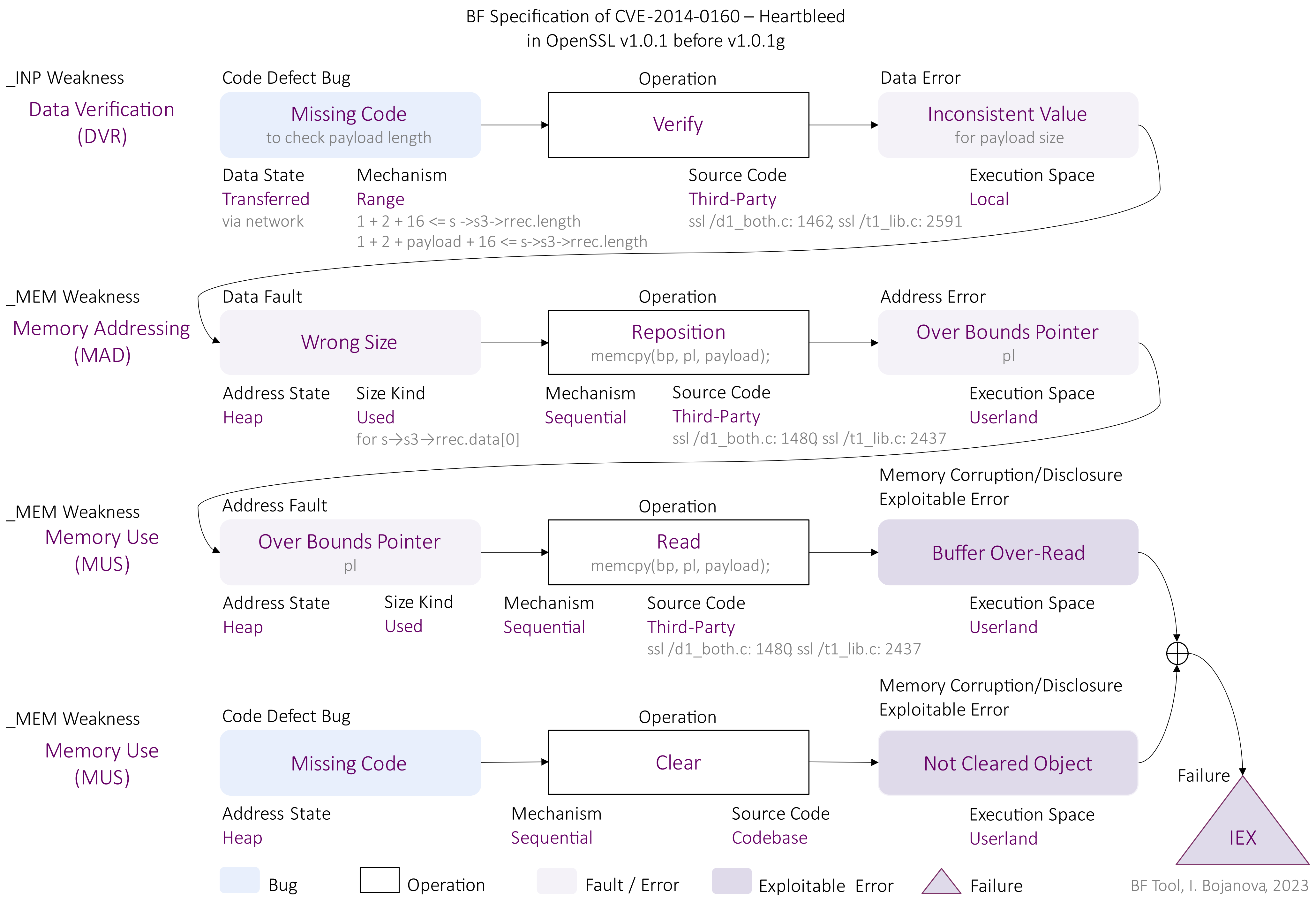
Potential Impact

- Clear communication between professionals and executives about cyber security bugs, weaknesses, exploitable errors, vulnerabilities, and failures; and software faults and errors.
- Unambiguous context for cybersecurity AI model training.

BF Vulnerability Specification Model



BF Specification of CVE-2014-0160 – Heartbleed



Missing verification of `payload` length towards an upper limit leads to use of an inconsistent size for an object, allowing a pointer reposition over its bounds, which, when used in `memcpy()` leads to a heap buffer over-read.
If exploited, this can lead to exposure of sensitive information – confidentiality loss.