FLP06-C. Convert integers to floating point for floating-point operations

Using integer arithmetic to calculate a value for assignment to a floating-point variable may lead to loss of information. This problem can be avoided by converting one of the integers in the expression to a floating type.

When converting integers to floating-point values, and vice versa, it is important to carry out proper range checks to avoid undefined behavior (see FLP34-C. Ensure that floating-point conversions are within range of the new type).

Noncompliant Code Example

In this noncompliant code example, the division and multiplication operations take place on integers and are then converted to floating point. Consequently, floating-point variables d, e, and f are not initialized correctly because the operations take place before the values are converted to floating-point values. The results are truncated to the nearest integer or may overflow.

```c
void func(void) {
    short a = 533;
    int b = 6789;
    long c = 466438237;
    float d = a / 7; /* d is 76.0 */
    double e = b / 30; /* e is 226.0 */
    double f = c * 789; /* f may be negative due to overflow */
}
```

Compliant Solution (Floating-Point Literal)

In this compliant solution, the decimal error in initialization is eliminated by ensuring that at least one of the operands to the division operation is floating point:

```c
void func(void) {
    short a = 533;
    int b = 6789;
    long c = 466438237;
    float d = a / 7.0f; /* d is 76.14286 */
    double e = b / 30.; /* e is 226.3 */
    double f = (double)c * 789; /* f is 368019768993.0 */
}
```

Compliant Solution (Conversion)

In this compliant solution, the decimal error in initialization is eliminated by first storing the integer in the floating-point variable and then performing the arithmetic operation. This practice ensures that at least one of the operands is a floating-point number and that the subsequent arithmetic operation is performed on floating-point operands.

```c
void func(void) {
    short a = 533;
    int b = 6789;
    long c = 466438237;
    float d = a;
    double e = b;
    double f = c;
    d /= 7; /* d is 76.14286 */
    e /= 30; /* e is 226.3 */
    f *= 789; /* f is 368019768993.0 */
}
```

Exceptions
FLP06-C-EX0: It may be desirable to have the operation take place as integers before the conversion (obviating the need for a call to `trunc()` for example). If this is the programmer's intention, it should be clearly documented to help future maintainers understand that this behavior is intentional.

**Risk Assessment**

Improper conversions between integers and floating-point values may yield unexpected results, especially loss of precision. Additionally, these unexpected results may actually involve overflow, or undefined behavior.

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Severity</th>
<th>Likelihood</th>
<th>Remediation Cost</th>
<th>Priority</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLP06-C</td>
<td>Low</td>
<td>Probable</td>
<td>Low</td>
<td>P6</td>
<td>L2</td>
</tr>
</tbody>
</table>

**Automated Detection**

<table>
<thead>
<tr>
<th>Tool</th>
<th>Version</th>
<th>Checker</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astrée</td>
<td>19.04</td>
<td>CertC-FLP06</td>
<td>Supported: This rule aims to prevent truncations and overflows. All possible overflows are reported by Astrée.</td>
</tr>
<tr>
<td>Axivion Bauhaus Suite</td>
<td>6.9.0</td>
<td>CertC-FLP06-a</td>
<td></td>
</tr>
<tr>
<td>CodeSonar</td>
<td>5.0p0</td>
<td>LANG.TYPE.MOT</td>
<td>Mismatched operand types</td>
</tr>
<tr>
<td>Compass /ROSE</td>
<td>9.7.1</td>
<td>435 S</td>
<td>Can detect violations of this rule. Any assignment operation where the type of the assigned-to value is float or double, but all the expressions to the right of the assignment are integral, is a violation of this rule</td>
</tr>
<tr>
<td>LDRA tool suite</td>
<td>10.4.2</td>
<td>CERT_C-FLP06-b</td>
<td>Implicit conversions from integral to floating type which may result in a loss of information shall not be used.</td>
</tr>
<tr>
<td>Parasoft C/C++test</td>
<td>9.5</td>
<td>4117 4118</td>
<td>Partially implemented</td>
</tr>
<tr>
<td>Polyspace Bug Finder</td>
<td>R2018a</td>
<td>Float overflow</td>
<td>Overflow from operation between floating points</td>
</tr>
<tr>
<td>PRQA QA-C</td>
<td>6.23</td>
<td>V636</td>
<td>The value of an expression shall not be assigned to an object with a narrower essential type or of a different essential type category.</td>
</tr>
<tr>
<td>Splint</td>
<td>3.1.1</td>
<td>V636</td>
<td></td>
</tr>
</tbody>
</table>

**Related Vulnerabilities**

Search for vulnerabilities resulting from the violation of this rule on the CERT website.

**Related Guidelines**

- CERT C Secure Coding Standard: FLP34-C. Ensure that floating-point conversions are within range of the new type
- SEI CERT C++ Coding Standard: VOID FLP05-CPP. Convert integers to floating point for floating point operations
- CERT Oracle Secure Coding Standard for Java: NUM50-J. Convert integers to floating point for floating-point operations
- MITRE CWE
  - CWE-681, Incorrect conversion between numeric types
  - CWE-682, Incorrect calculation

**Bibliography**

- [Hatton 1995] Section 2.7.3, “Floating-Point Misbehavior”