Abstract

The mere act of lexing C++ can result in undefined behavior. This paper removes that undefined behavior. Further work will be needed to remove all undefined behavior in [cpp].

Revisions

Revision 2

• Apply CWG feedback from Issaquah

Revision 1

• Fix typos

Motivation

According to the standard, the following examples expose undefined behavior:

```cpp
int \ // UB: universal character name across spliced lines
u\0393
1 = 0;
```

```cpp
#define CONCAT(x, y) x ## y
int CONCAT(\, u0393) = 0; // UB: universal character name formed by macro expansion
```

```cpp
// UB: unterminated string
const char * foo = "
```

It does seem unfortunate that lexing C++ would incur UB. As such, we propose to change the specification to remove the UB by either well-defining the behavior or making it ill-formed, closely matching implementations. The status-quo, as well as the proposed changes, are
summarized below. The red cell highlights the only impact this paper would have on existing implementations.

<table>
<thead>
<tr>
<th></th>
<th>GCC</th>
<th>CLANG</th>
<th>EDG</th>
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<tbody>
<tr>
<td>Spliced UCN</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Error</td>
<td>Well-formed</td>
</tr>
<tr>
<td>UCN Produced BY ##</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Well-formed</td>
</tr>
<tr>
<td>Untermminated &quot; or '</td>
<td>ill-formed</td>
<td>ill-formed</td>
<td>ill-formed</td>
<td>ill-formed</td>
<td>ill-formed</td>
</tr>
</tbody>
</table>

We propose that spliced UCNs be supported because, in addition to 3/4 of surveyed compilers supporting it, it falls off naturally of the specification: splicing happens before any other form of tokenization and supporting it avoid special-casing this oddity.

**Wording**

**Phases of translation**

2. Each sequence of a backslash character (\) immediately followed by zero or more whitespace characters other than new-line followed by a new-line character is deleted, splicing physical source lines to form logical source lines. Only the last backslash on any physical source line shall be eligible for being part of such a splice. **Except for splices reverted in a raw string literal, if a splice results in a character sequence that matches the syntax of a universal-character-name, the behavior is undefined.**

[Note: Line splicing can form a universal-character-name [lex.charset]. — end note]

A source file that is not empty and that does not end in a new-line character, or that ends in a splice, shall be processed as if an additional new-line character were appended to the file.

A preprocessing token is the minimal lexical element of the language in translation phases 3 through 6. In this document, glyphs are used to identify elements of the basic character set[lex.charset]. The categories of preprocessing token are: header names, placeholder tokens produced by preprocessing import and module directives (import-keyword, module-keyword, and export-keyword), identifiers, preprocessing numbers, character literals (including user-defined character literals), string literals (including user-defined string literals), preprocessing operators and punctuators, and single non-whitespace characters that do not lexically match the other preprocessing token categories. If a U+0027 APOSTROPHE or a U+0022 QUOTATION MARK matches the last category, the behavior is undefined. program is ill-formed. If any character not in the basic character set matches the last category, the program is ill-formed.

**The ## operator**

A ## preprocessing token shall not occur at the beginning or at the end of a replacement list for either form of macro definition.
If, in the replacement list of a function-like macro, a parameter is immediately preceded or followed by a ## preprocessing token, the parameter is replaced by the corresponding argument’s preprocessing token sequence; however, if an argument consists of no preprocessing tokens, the parameter is replaced by a placemaker preprocessing token instead. For both object-like and function-like macro invocations, before the replacement list is reexamined for more macro names to replace, each instance of a ## preprocessing token in the replacement list (not from an argument) is deleted and the preceding preprocessing token is concatenated with the following preprocessing token. Placemaker preprocessing tokens are handled specially: concatenation of two placemarkers results in a single placemaker preprocessing token, and concatenation of a placemaker with a non-placemaker preprocessing token results in the non-placemaker preprocessing token. If the result begins with a sequence matching the syntax of universal-character-name, the behavior is undefined. [Note: This determination does not consider the replacement of universal-character-name s in translation phase 3[lex.phases]. — end note] [Note: Concatenation can form a universal-character-name. — end note] If the result is not a valid preprocessing token, the behavior is undefined. The resulting token is available for further macro replacement. The order of evaluation of ##

**Future work**

The reader will have noticed that [cpp] has a few other undefined behaviors. This should equally be fixed, however, this work is best left to someone with greater preprocessor expertise.