Technical Reports

Proposed Draft
Unicode Technical Report #29

TEXT BOUNDARIES

Version	1
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Date	2001-03-11
This Version	http://www.unicode.org/reports/tr29/tr29-1.html
Previous Version	n/a
Latest Version	http://www.unicode.org/reports/tr29
Tracking Number	1

Summary

This document describes guidelines for determining default boundaries between certain significant text elements: grapheme clusters ("user characters"), words, and sentences. For the related line-break boundaries, see UAX #14: Line Breaking Properties.

Status

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Contents

1 Introduction

This document describes guidelines for determining default boundaries between certain significant text elements: grapheme clusters ("user characters"), words, and sentences. It updates most of 5.15 Locating Text Element Boundaries, except for the line-break boundaries, which are covered in UAX #14: Line Breaking Properties.

A string of Unicode-encoded text often needs to be broken up into text elements programmatically. Common examples of text elements include what users think of as characters, words, lines, and sentences. The precise determination of text elements may vary according to locale, even as to what constitutes a character. The goal of matching user perceptions cannot always be met because the text alone does not always contain enough information to unambiguously decide boundaries. For example, the *period* (U+002E FULL STOP) is used ambiguously, sometimes for end-of-sentence purposes, sometimes for abbreviations, and sometimes for numbers. In most cases, however, programmatic text boundaries can match user perceptions quite closely, or at least not surprise the user.

Rather than concentrate on algorithmically searching for text elements themselves, a simpler and more useful computation looks instead at detecting the *boundaries* between those text elements. The determination of those boundaries is often critical to the performance of general software, so it is important to be able to make such a determination as quickly as possible.

The following boundary determination mechanism provides a straightforward and efficient way to determine certain default significant boundaries in text. It builds upon the uniform character representation of the Unicode Standard, while handling the large number of characters and special features such as combining marks and surrogates in an effective manner. As this boundary determination mechanism lends itself to a completely data-driven implementation, it can be tailored to particular locales or user preferences without recoding.

For some languages, this basic mechanism is not sufficient. For example, Thai line-break or word-break boundaries requires the use of dictionary lookup, analogous to English hyphenation. An implementation therefore may need to provide means to override or subclass the default mechanism described in this document.

The large character set of the Unicode Standard and its representational power place requirements on both the specification of text element boundaries and the underlying implementation. The specification needs to allow for the designation of large sets of characters sharing the same characteristics (for example, uppercase letters), while the implementation must provide quick access and matches to those large sets. The mechanism also must handle special features of the Unicode Standard, such as combining or nonspacing marks, conjoining jamo, and surrogate characters.

1.1 Notation

A boundary specification defines different classes, then lists the rules for boundaries in terms of those classes. The character classes are specified as a list, where each element of the list is

- A literal character
- A range of characters
- A property of a Unicode character, as defined in the Unicode Character Database
- Boolean combinations of the above

For more information, see UTR #18: Unicode Regular Expression Guidelines.

The rules are numbered for reference and are applied in order. That is, there is an implicit “otherwise” at the front of each rule following the first.

Additional notational conventions used in the rules are as follows:

÷	Allow break here.
×	Do not allow break here.

An *underscore* (“_”) is used to indicate a space in examples.

As in other cases, these are a *logical* descriptions of the processes: implementations can achieve the same results without following these rules precisely. In particular, most production-grade implementations will use a state-table approach. In that case, the performance does not depend on the complexity or number of rules. The only feature that does affect performance is the number of characters that may match *after* the boundary position in a rule that is matched.

Some additional constraints are reflected in the specification. These constraints make the implementation significantly simpler and more efficient and have not been found to be limitations for natural language use.

1. *Single boundaries.* Each rule has exactly one boundary position. Because of constraint (1), this restriction is more a limitation on the specification methods, because a rule with two boundaries could generally be expressed as two rules. For example, “ab÷cd÷ef” could be broken into “ab÷cd” and “cd÷ef”.
2. *Ignore degenerates.* No special provisions are made to get marginally better behavior for degenerate cases that never occur in practice, such as an *A* followed by an Indic combining mark.

Different issues are present with different types of boundaries, as the following discussion and examples should make clear.

2 Grapheme Cluster Boundaries

One or more Unicode characters may make up what the user thinks of as a character or basic unit of the language. To avoid ambiguity with the computer use of the term *character,* this is called a *grapheme cluster*. For example, “G” + *acute-accent* is a grapheme cluster: it is thought of as a single character by users, yet is actually represented by two Unicode code points. For more information on the ambiguity in the term *character*, see Unicode Technical Report #17, “Character Encoding Model”.

Grapheme clusters include, but are not limited to, combining character sequences such as (g + °), digraphs such as Slovak “ch”, and sequences with letter modifiers such as k^w. Grapheme cluster boundaries are important for collation, regular-expressions, and counting “character” positions within text. Word breaks, line breaks and sentence breaks do not occur within a grapheme cluster. In this section, the Unicode Standard provides a determination of where the default grapheme boundaries fall in a string of characters. This algorithm can be tailored for specific locales or other customizations, which is what is done in providing contracting characters in collation tailoring tables.

> **Note**: In previous documentation, default grapheme clusters were previously referred to as "locale-independent graphemes". The term *cluster* has been added to emphasize that the term *grapheme* as used differently in linguistics. For simplicity and to align with UTS #10: Unicode Collation Algorithm, the terms *default* and *tailored* are used in preference to *locale-independent* and *locale-dependent*, respectively.

As far as a user is concerned, the underlying representation of text is not important, but it is paramount that an editing interface present a uniform implementation of what the user thinks of as characters. Grapheme clusters commonly behave as units in terms of mouse selection, arrow key movement, backspacing, and so on. When this is done, for example, and an accented character is represented by a combining character sequence, then using the right arrow key would skip from the start of the base character to the end of the last combining character. In some cases, particularly for spacing combining marks, editing a grapheme cluster element by element may be the preferred way. In those rare circumstances where end-users need character counts, the counts need to correspond to the grapheme cluster boundaries.

The principal requirements for default grapheme cluster boundaries are the handling of combining marks, Hangul conjoining jamo, and Indic and Tibetan character clusters. Boundaries may be further tailored for requirements of different languages, such as the addition of “ch” for Slovak. For the rules defining the default boundaries, see *Table 1, Default Grapheme Cluster Boundaries* below.

Table 1. Default Grapheme Cluster Boundaries

Character Classes

sot	Start of Text
eot	End of Text
CR	Carriage Return
LF	Line Feed
Control	Line Separator, Paragraph Separator *or* General Category = Control
CGJ	Combining Grapheme Joiner
Link	`Grapheme_Link`, as determined by the UCD. Includes most viramas but not the CGJ.
Extend	`Grapheme_Extend`, as determined by the UCD. Includes combining marks (except for the CGJ and Link) and format controls.
Base	`Grapheme_Base`, as determined by the UCD. **Note**: includes L, V, T, LV, LVT.
LetterBase	General Category = Letter
L	Hangul leading jamo: U+1100..U+115F
V	Hangul vowel jamo: U+1160..U+11A2
T	Hangul trailing jamo: U+11A8..U+11F9
LV	Precomposed Hangul syllable that is canonically equivalent to a sequence of <L,V>
LVT	Precomposed Hangul syllable that is canonically equivalent to a sequence of <L,V,T>
Any	Any character (includes all of the above except sot and eot)

Rules

Break before the start of text and after the end.			
	÷	sot	(1)
eot	÷		(2)
Do not break between a CR and LF. Otherwise break before and after controls.			
CR	×	LF	(3)
Control	÷		(4)
	÷	Control	(5)
Do not break Hangul syllable sequences.			
L	×	(L | V | LV | LVT)	(6)
(LV | V)	×	(V | T)	(7)
(LVT | T)	×	T	(8)
Don't break before extending characters.			
	×	Extend	(9)
Do not break around a CGJ.			
CGJ	×	Base	(10)
	×	CGJ	(11)
Do not break between linking characters and letters, or before linking characters. This provides for Indic graphemes, where virama (halant) *will link character clusters together.*			
Link Extend*	×	LetterBase	(12)
	×	Link	(13)
Otherwise break after all characters.			
Any	÷		(14)

A default grapheme cluster normally begins with a base character. Exceptions include when a combining mark is at the start of text, or it is preceded by a control or format character. Except for the Extend characters, the boundary of a default grapheme cluster can be determined by just the adjacent characters. As in LineBreak, it only requires a minor modification for programs to skip over the Extend characters where required.

For more information on the composition of Hangul Syllables (with L, V, or T) see 3.11 Conjoining Jamo Behavior (revision) in UAX #28: Unicode Version 3.2.

Degenerate Cases. As with other definitions in Chapter 5 and elsewhere, such definitions are designed to be simple to implement. They need to provide an algorithmic determination of the valid, default grapheme clusters, and exclude sequences that are normally not considered default grapheme clusters. However, they do *not* have to catch edge cases that will not occur in practice. Mismatched sequences such as `<DEVANAGARI KA, COMBINING GRAPHEME JOINER, HANGUL JONGSEONG YEORINHIEUH, COMBINING ACUTE>` may end up being characterized as a single default grapheme cluster, but it is not worth the extra complications in the definition that would be required to catch all of these cases, because they will not occur in practice.

The definition of default grapheme clusters is not meant to exclude the use of more sophisticated definitions of tailored grapheme clusters where appropriate: definitions that more precisely match the user expectations within individual languages. For example, “ch” may be considered a grapheme cluster in Slovak. It is, however, designed to provide a much more accurate match to overall user expectations for *characters* than is provided by individual Unicode code points.

Display of Grapheme Clusters. Grapheme clusters are not the same as ligatures. For example, the grapheme cluster “ch” in Slovak is not normally a ligature, and conversely, the ligature “fi” is not normally a grapheme cluster. Default grapheme clusters do not necessarily reflect text display. For example, the sequence <f, i> may be displayed as a single glyph on the screen, but would still be two grapheme clusters.

For more information on the use of grapheme clusters, see Unicode Technical Report #18, “Unicode Regular Expression Guidelines”.

Issue: Should we add Thai/Lao clusters, by adding a rule:

Logical_Order_Exception $\times$ Base

and adding additional characters to the Extend class?

3 Word Boundaries

Word boundaries are used in a number of different contexts. The most familiar ones are double-click mouse selection, “move to next word,” and "Whole Word Search" (WWS) for search and replace. They are also used in database queries, to determine whether elements are within a certain number of words of one another.

Word boundaries can also be used in so-called *intelligent cut and paste*. With this feature, if the user cuts a piece of text on word boundaries, adjacent spaces are collapsed to a single space. For example, cutting “quick” from “The_quick_fox” would leave “The_ _fox”. Intelligent cut and paste collapses this text to “The_fox”.

The word boundaries are related to the line boundaries, but are distinct. Here is an example of word boundaries.

Example 1: Word Boundaries

The		quick		(	"	brown	"	)		fox		can't		jump		32.3		feet	,		right	?

There is a boundary, for example, on either side of the word *brown*. These are the boundaries that users would expect, for example, if they chose WWS. Matching *brown* with WWS works, since there is a boundary on either side. Matching *brow* doesn't. Matching *"brown"* also works, since there are boundaries between the parentheses and the quotation marks.

For proximity tests, one sees whether, for example, "monster" is within 3 words of "truck". That is done with the above boundaries by ignoring any words that contain a letter (or digit: whether or not digits are included is task-specific). Thus for proximity we get the following, so "fox" is within three words of "quick".

Example 2: Extracted Words

The	quick	brown	fox	can't	jump	32.3	feet	right

There are other cases where the characters between given boundaries are ignored, based on the types of characters.

> Note: As with the other default specifications, implementations are free to override (tailor) the results to meet the requirements of different environments or particular languages.

Table 5-4. Default Word Boundaries

Character Classes

sot	Start of Text
eot	End of Text
Hiragana	General_Category = Letter AND Script = HIRAGANA
Katakana	General_Category = Letter AND Script = KATAKANA
Letter	(General_Category = Letter OR General_Category = Modifier_Symbol) AND ¬ (Line_Break = Ideographic OR Hiragana OR Katakana)
MidLetter	U+0027 (') *apostrophe*, U+2019 (') *curly apostrophe*, U+003A (:) *colon* (used in Swedish), U+0029 (.) *period*, U+00AD (●) *soft hyphen*, U+05F3 (׳) *geresh*, U+05F4 (״) *gershayim*
other	Other categories are from Line_Break (using the long names from PropertyAliases

Rules

Treat a grapheme cluster as if it were a single character: the first base character, if there is one; otherwise the first character.			
GC => FB			(1)
Don't break between most letters			
Letter	×	Letter	(2)
Don't break letters across certain punctuation			
Letter	×	MidLetter Letter	(3)
Letter MidLetter	×	Letter	(4)
Don't break within sequences of digits, or digits adjacent to letters.			
Numeric	×	Numeric	(5)
Letter	×	Numeric	(6)
Numeric	×	Letter	(7)
Don't break within sequences like: '–3.2'			
Hyphen	×	Numeric	(8)
Numeric Infix_Numeric	×	Numeric	(9)
Numeric	×	Infix_Numeric Numeric	(10)
Prefix_Numeric	×	Numeric	(11)
Numeric	×	Postfix_Numeric	(12)
Don't break between Hiragana or Katakana			
Hiragana	×	Hiragana	(13)
Katakana	×	Katakana	(14)
Otherwise, break everywhere (including around ideographs)			
Any	÷		(15)
	÷	Any	(16)

Notes:

- Unfortunately we cannot resolve all of the issues across languages (or even within a language, since there are ambiguities). The goal is to have as workable a default as we can; tailored engines can be more sophisticated about these matters.
-
  Thai is a case where, as in LineBreak, a good implementation should not just depend on the default word boundary specification, but should use a more sophisticated mechanism. There must be some default, however, in the absence of such a mechanism. The above treats any sequence of Thai letters as a single word, depending on the (logical or physical) insertion of ZWSP to break up

the words.

- The hard hyphen is a tricky case. It is quite common for separate words to be connected with a hyphen: out-of-the-box, under-the-table, Anglo-american, etc. A significant number are hyphenated names: Smith-Hawkins, etc. When people do a "Whole Word" search or query, they expect to find the word within those hyphens. While there are some cases where they are separate words (usually to resolve some ambiguity such as re-sort vs resort) it's better overall to keep the hard hyphen out of the default definition.
- Apostrophe is another one. Usually considered part of one word ("can't", "aujourd'hui") it may also be considered two ("l'objectif"). Also, one cannot easily distinguish the cases where it is used as a quotation mark from those where it is used as an apostrophe, so one should not include leading or trailing apostrophes. In some languages, such as French, tailoring it to break words may yield better results in more cases.
- Certain cases like colon in words (c:a) are included even though they may be specific to relatively small user communities (Swedish) because they don't occur otherwise in normal text, and so don't cause a problem for other languages.

Issue: Would a better default for Thai/Lao be treating them as breaking on grapheme cluster boundaries?

4 Sentence Boundaries

Sentence boundaries are often used for triple-click or some other method of selecting or iterating through blocks of text that are larger than single words. They is also used to determine whether words occur within the same sentence in database queries.

Plain text provides inadequate information for determining good sentence boundaries. Periods, for example, can either signal the end of a sentence, indicate abbreviations, or be used for decimal points. Remember that these are, like the others, default boundaries, and may be tailored. One cannot, without much more sophisticated analysis, distinguish between cases like:

He said, "Are you going?"	Mr. Smith shook his head.
"Are you going?" Mr. Smith asked.	

Without analyzing the text semantically, it is impossible to be certain which of these usages is intended (and sometimes ambiguities still remain).

Table 5-6. Default Sentence Boundaries

Character Classes

CR	Carriage Return
LF	Linefeed
Sep	CR | LF | NEL | LS | PS
Sp	Whitespace - Sep
Term	Terminal_Punctuation1 OR Terminal_Punctuation2
ATerm	Terminal_Punctuation2
Lower	Lowercase OR General_Category = Letter OR General_Category = Modifier_Symbol
Upper	Uppercase | General_Category = Titlecase_Letter
Open	General_Category = Open_Punctuation

Rules

Treat a grapheme cluster as if it were a single character: the first base character, if there is one; otherwise the first character.			
GC => FB			(1)
Don't break CRLF; otherwise break after paragraph separators			
CR	×	LF	(2)
Sep	÷		(3)
Don't break after ambiguous terminators like period if the first following letter is lowercase, or if the preceding word is contains an uppercase letter. For example, a period may be an abbreviation or numeric period, and not mark the end of a sentence.			
ATerm Close* Sp* {Sep}	×	(¬Letter)* Lowercase	(4)
Upper Lower* ATerm Close* Sp* {Sep}	×		(5)
Break after sentence terminators, but include closing punctuation, trailing spaces, and (optionally) a paragraph separator.			
Term Close* Sp* {Sep}	÷		(6)

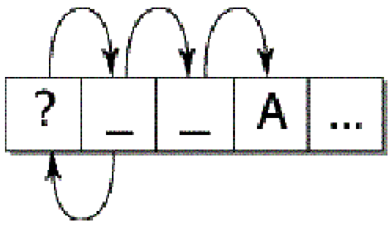
Issue: We have to determine the contents of the different useful subsets of the Terminal_Punctuation property in the Unicode Character Database . The following is a rough initial cut.

```
  Terminal_Punctuation1: characters that definitely ends sentences.
  0021          ; Terminal_Punctuation # Po       EXCLAMATION MARK
  003F          ; Terminal_Punctuation # Po       QUESTION MARK
  037E          ; Terminal_Punctuation # Po       GREEK QUESTION MARK
  061F          ; Terminal_Punctuation # Po       ARABIC QUESTION MARK
  06D4          ; Terminal_Punctuation # Po       ARABIC FULL STOP
  203C..203D    ; Terminal_Punctuation # Po   [2] DOUBLE EXCLAMATION MARK..INTERROBANG
  3002          ; Terminal_Punctuation # Po       IDEOGRAPHIC FULL STOP
  2048..2049    ; Terminal_Punctuation # Po   [2] QUESTION EXCLAMATION MARK..EXCLAMATION QUESTION MARK

  Terminal_Punctuation2: characters that could be part of an abbreviation or end a sentence.
  002E          ; Terminal_Punctuation # Po       FULL STOP
  0589          ; Terminal_Punctuation # Po       ARMENIAN FULL STOP
  3001          ; Terminal_Punctuation # Po       IDEOGRAPHIC COMMA

  Terminal_Punctuation3: characters irrelevant to sentence boundaries
  002C          ; Terminal_Punctuation # Po       COMMA
  003A..003B    ; Terminal_Punctuation # Po   [2] COLON..SEMICOLON
  0387          ; Terminal_Punctuation # Po       GREEK ANO TELEIA
  060C          ; Terminal_Punctuation # Po       ARABIC COMMA
  061B          ; Terminal_Punctuation # Po       ARABIC SEMICOLON

  Not yet determined
  0700..070A    ; Terminal_Punctuation # Po  [11] SYRIAC END OF PARAGRAPH..SYRIAC CONTRACTION
  070C          ; Terminal_Punctuation # Po       SYRIAC HARKLEAN METOBELUS
  0964..0965    ; Terminal_Punctuation # Po   [2] DEVANAGARI DANDA..DEVANAGARI DOUBLE DANDA
  0E5A..0E5B    ; Terminal_Punctuation # Po   [2] THAI CHARACTER ANGKHANKHU..THAI CHARACTER KHOMUT
  104A..104B    ; Terminal_Punctuation # Po   [2] MYANMAR SIGN LITTLE SECTION..MYANMAR SIGN SECTION
  1361..1368    ; Terminal_Punctuation # Po   [8] ETHIOPIC WORDSPACE..ETHIOPIC PARAGRAPH SEPARATOR
  166D..166E    ; Terminal_Punctuation # Po   [2] CANADIAN SYLLABICS CHI SIGN..CANADIAN SYLLABICS FULL STOP
  16EB..16ED    ; Terminal_Punctuation # Po   [3] RUNIC SINGLE PUNCTUATION..RUNIC CROSS PUNCTUATION
  17D4..17D6    ; Terminal_Punctuation # Po   [3] KHMER SIGN KHAN..KHMER SIGN CAMNUC PII KUUH
  17DA          ; Terminal_Punctuation # Po       KHMER SIGN KOOMUUT
  1802..1805    ; Terminal_Punctuation # Po   [4] MONGOLIAN COMMA..MONGOLIAN FOUR DOTS
  1808..1809    ; Terminal_Punctuation # Po   [2] MONGOLIAN MANCHU COMMA..MONGOLIAN MANCHU FULL STOP
```

5 Random Access

A further complication is introduced by random access. When iterating through a string from beginning to end, the above mechanism works well. It guarantees a limited context, and it allows a fresh start at each boundary to find the next boundary. By constructing a state table for the reverse direction from the same specification of the rules, reverse searches are possible. However, suppose that the user wants to iterate starting at a random point in the text. If the starting point does not provide enough context to allow the correct set of rules to be applied, then one could fail to find a valid boundary point. For example, suppose a user clicked after the first space in “?_ _A”. On a forward iteration searching for a sentence boundary, one would fail to find the boundary before the “A”, because the “?” hadn’t been seen yet.

A second set of rules to determine a “safe” starting point provides a solution. Iterate backward with this second set of rules until a safe starting point is located, then iterate forward from there. Iterate forward to find boundaries that were located between the safe point and the starting point; discard these. The desired boundary is the first one that is not less than the starting point.



This process would represent a significant performance cost if it had to be performed on every search. However, this functionality could be wrapped up in an iterator object, which preserves the information regarding whether it currently is at a valid boundary point. Only if it is reset to an arbitrary location in the text is this extra backup processing performed.

References

[FAQ]	Unicode Frequently Asked Questions http://www.unicode.org/unicode/faq/ *For answers to common questions on technical issues.*
[Glossary]	Unicode Glossary http://www.unicode.org/glossary/ *For explanations of terminology used in this and other documents.*
[Reports]	Unicode Technical Reports http://www.unicode.org/unicode/reports/ *For information on the status and development process for technical reports, and for a list of technical reports.*
[U3.1]	Unicode Standard Annex #27: Unicode 3.1 http://www.unicode.org/unicode/reports/tr27/
[Versions]	Versions of the Unicode Standard http://www.unicode.org/unicode/standard/versions/ *For details on the precise contents of each version of the Unicode Standard, and how to cite them.*

Modifications

The following summarizes modifications from the previous version of this document.

6	Combined revision proposals into single document.