Summary

This technical report specifies an algorithm that can be utilized during rendering for determining correct display of Arabic combining mark sequences.

This UTR makes no change to Unicode normalization forms, and does not propose a new normalization form. Instead, this is similar to the processing used in MicrosoftUSE: a transient process which is used to reorder text for display in an internal rendering pipeline. This reordering is not intended for modifying original text, nor for open interchange.

Status

This is a draft document which may be updated, replaced, or superseded by other documents at any time. Publication does not imply endorsement by the Unicode Consortium. This is not a stable document; it is inappropriate to cite this document as other than a work in progress.

A Unicode Technical Report (UTR) contains informative material. Conformance to the Unicode Standard does not imply conformance to any UTR. Other specifications, however, are free to make normative references to a UTR.

Please submit corrigenda and other comments with the online reporting form [Feedback]. Related information that is useful in understanding this document is found in the References. For the latest version of the Unicode Standard see [Unicode]. For a list of current Unicode Technical Reports see [Reports]. For more information about versions of the Unicode Standard, see [Versions].

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Overview

The combining classes of Arabic combining characters in Unicode are different than combining classes in most other scripts. They are:

- \( \text{ccc} = \) 0: Special classes for specific marks
- \( \text{ccc} > 0 \): Generalized classes for all the other marks

This has resulted in inconsistent and/or incorrect rendering for sequences with multiple combining marks since Unicode 2.0.

The Arabic Mark Transient Reordering Algorithm (AMTRA) described herein is the recommended solution to achieving correct and consistent rendering of Arabic combining mark sequences. This algorithm provides results that match user expectations and assures that canonically equivalent sequences are rendered identically, independent of the order of the combining marks.

Background

Rules and recommendations for the correct display of combining marks are discussed in a number of places in the Unicode Standard, including Section 5.13, Unknown and Missing Characters, Section 7.9, Combining Marks, and Section 9.2, Arabic. Some general principles include:

- Canonically equivalent sequences should display the same.
- Combining marks from the same combining class are normally displayed using the inside-out rule, that is, from the base outward.
- Combining marks from different combining classes (other than \( \text{ccc}=0 \)) may be re-ordered with respect to each other if that helps to achieve the desired display.

In Unicode, the Arabic script combining marks include eleven different non-zero Canonical_Combining_Class values, as shown in Table 1. When a combining character sequence includes marks from more than one of these classes, the rendering system has to determine a display order in which to position these marks on the base character.

While it might be tempting to just use NFC or NFD, neither of these normalization forms will yield what Arabic readers expect. For one example that will be easily understood by all readers of Arabic script, given a combining character sequence including a shadda (ccc=33) and damma (ccc=31), NFC and NFD will move the damma before the shadda—at which point the default inside-out rendering rule would place the shadda above the damma, which is incorrect.

Some cases are obvious to readers of languages written with Arabic script, and thus will likely get the same display from various rendering implementations. However, many of the combining marks, especially those with \( \text{ccc}=220 \) and \( \text{ccc}=230 \), are not commonly understood. Different rendering implementations have made different decisions regarding display order, resulting in inconsistent behavior between one system and another.

AMTRA defines a method to reorder Arabic combining marks in order to accomplish the following goals:

- The inside-out rendering rule will display combining marks in the expected visual order.
- Ensure identical display of canonically equivalent sequences.
- Provide a mechanism for overriding the display order in exceptional cases.
### Table 1: Canonical Combining Class Values for Marks Used in Arabic Script

<table>
<thead>
<tr>
<th>Canonical Combining Class (ccc) Value</th>
<th>Combining Marks in this Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Combining grapheme joiner</td>
</tr>
<tr>
<td>27</td>
<td>fathatan, open fathatan</td>
</tr>
<tr>
<td>28</td>
<td>dammatan, open dammatan</td>
</tr>
<tr>
<td>29</td>
<td>kasratan, open kasratan</td>
</tr>
<tr>
<td>30</td>
<td>fatha, small fatha</td>
</tr>
<tr>
<td>31</td>
<td>damma, small damma</td>
</tr>
<tr>
<td>32</td>
<td>kasra, small kasra</td>
</tr>
<tr>
<td>33</td>
<td>shadda</td>
</tr>
<tr>
<td>34</td>
<td>sukun</td>
</tr>
<tr>
<td>35</td>
<td>Superscript alef</td>
</tr>
<tr>
<td>220</td>
<td>All other below combining marks except small low noon with kasra</td>
</tr>
<tr>
<td>230</td>
<td>All other above combining marks small low noon with kasra</td>
</tr>
</tbody>
</table>

### 3 Description of the Algorithm

The algorithm starts by reordering combining marks according to one of the Unicode Normalization forms, and then makes adjustments by moving certain marks closer to the base.

#### 3.1 Modifier Combining Marks (MCM)

For use by this algorithm, this specification defines a group of combining marks called "Modifier Combining Marks" (MCM). MCM are combining characters that are normally used to modify the base character before them, and should normally be rendered closer to the base character than *tashkil* (supplementary diacritics, including vowels). The MCM characters are not formally classified as *ijam* (consonant pointing/nukta, and so on) in the Unicode Standard, but they are usually perceived by users as *ijam*.

The complete list of MCM characters is:

- U+0654 ARABIC HAMZA ABOVE
- U+0655 ARABIC HAMZA BELOW
- U+0658 ARABIC MARK NOON GHUNNA
- U+06DC ARABIC SMALL HIGH SEEN
- U+06E3 ARABIC SMALL LOW SEEN
- U+06E7 ARABIC SMALL HIGH YEH
- U+06E8 ARABIC SMALL HIGH NOON
- U+08CA ARABIC SMALL HIGH Farsi YEH
- U+08CB ARABIC SMALL HIGH YEH BARREE WITH TWO DOTS BELOW
- U+08CD ARABIC SMALL HIGH ZAH
- U+08CE ARABIC LARGE ROUND DOT ABOVE
- U+08CF ARABIC LARGE ROUND DOT BELOW
- U+08D3 ARABIC SMALL LOW WAW
- U+08F3 ARABIC SMALL HIGH WAW

The set of MCM characters is stable. Adding an existing Unicode character to the list of MCM could change the rendering of data that assumes the implementation of AMTRA. Additional characters may be added to the MCM at the time they are encoded (see Section 5.4 **Rationale for Exclusion of Some Marks**).

### 3.2 Specification of AMTRA
In the following specification, parenthetical definitions, for example (D56), refer to definitions in the Unicode core specification.

**Input:** A Combining Character Sequence (D56) containing one or more Arabic combining marks.

**Output:** A canonically equivalent Combining Character Sequence reordered for rendering using inside-out stacking.

Steps:

1. Normalize the input to NFD
2. Within the result, for each maximal-length substring, S, of non-starter (D107) characters, re-order as follows:
   a. Move any shadda characters (ccc=33) to the beginning of S.
   b. If a sequence of ccc=230 characters begins with any MCM characters, move the sequence of such MCM characters to the beginning of S (before any characters with ccc=33).
   c. If a sequence of ccc=220 characters begins with any MCM characters, move the sequence of such MCM characters to the beginning of S (before any MCM with ccc=230 or ccc=33).

### 4 Demonstrating AMTRA

#### 4.1 Artificial Test Case

The following figure demonstrates the algorithm using an artificial sequence of characters:

**Input**

```
| fatha 0618 (30) | damma 0619 (31) | fatha 064E (30) | damma 064F (31) | hamza 0654 (230) | noon 0658 (230) | madda 0655 (230) | shadda 0651 (33) | sb. alef 0656 (220) | shadda 0651 (33) | mimala 065C (220) | hamza 0655 (220) | hamza 0654 (220) | kasra 0650 (32) |
```

**After Step 1**

```
| shadda 0651 (33) | shadda 0651 (33) | fatha 0618 (30) | fatha 064E (30) | damma 0619 (31) | damma 064F (31) | kasra 0650 (32) | shadda 0651 (33) | shadda 0651 (33) | sb. alef 0656 (220) | mimala 065C (220) | hamza 0655 (220) | hamza 0654 (220) | noon 0658 (230) | madda 0655 (230) | hamza 0654 (230) |
```

**After Step 2a (MCM denoted in dark blue)**

```
| hamza 0654 (230) | noon 0658 (230) | shadda 0651 (33) | shadda 0651 (33) | fatha 0618 (30) | fatha 064E (30) | damma 0619 (31) | damma 064F (31) | kasra 0650 (32) | sb. alef 0656 (220) | mimala 065C (220) | hamza 0655 (220) | hamza 0654 (220) | noon 0658 (230) | madda 0655 (230) | hamza 0654 (230) |
```

**After Step 2b**

```
| hamza 0654 (230) | noon 0658 (230) | shadda 0651 (33) | shadda 0651 (33) | fatha 0618 (30) | fatha 064E (30) | damma 0619 (31) | damma 064F (31) | kasra 0650 (32) | sb. alef 0656 (220) | mimala 065C (220) | hamza 0655 (220) | hamza 0654 (220) | noon 0658 (230) | madda 0655 (230) | hamza 0654 (230) |
```

**After Step 2e – final display order (No MCM at start of ccc=220 group)**

```
| hamza 0654 (230) | noon 0658 (230) | shadda 0651 (33) | shadda 0651 (33) | fatha 0618 (30) | fatha 064E (30) | damma 0619 (31) | damma 064F (31) | kasra 0650 (32) | sb. alef 0656 (220) | mimala 065C (220) | hamza 0655 (220) | hamza 0654 (220) | noon 0658 (230) | madda 0655 (230) | hamza 0654 (230) |
```

#### 4.2 Override Mechanism for Exceptions

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https://www.unicode.org/reports/tr53/tr53-7.html
The default display order implemented by the AMTRA will be correct for most uses. However in situations where a different mark order is desired, U+034F COMBINING GRAPHEME JOINER (CGJ) can be used to achieve the desired display order. The following sections give examples of the use of CGJ.

4.3 Examples

The following examples demonstrate why each of the respective characters is included in the MCM.

_U+0654 ARABIC HAMZA ABOVE and U+0655 ARABIC HAMZA BELOW_

The use of combining hamza above and below is discussed in Section 9.2, Arabic [Unicode].

**Example 1** [Quran1] (page 9, end of line 5)

In Example 1, AMTRA puts a _damma_ over a _hamza above_:

If an orthography needs to put the _hamza above_ over the _damma_, the text should be encoded as

<damma, CGJ, hamza above>:

**AMTRA puts the _kasra_ below a _hamza below_**:
If an orthography needs to put the hamza below under the kasra, the text should be encoded as <kasra, CGJ, hamza below>:

```
U+0658 ARABIC MARK NOON GHUNNA
```

Regarding inclusion of this mark in the MCM, Kew says “The ARABIC NASALIZATION MARK is considered equivalent to a ‘nukta’, as it is a modifier that binds tightly to the underlying letter.” (italics added for emphasis) [Kew]. The character is the character encoded as U+0658 ARABIC MARK NOON GHUNNA.

```
U+06DC ARABIC SMALL HIGH SEEN and U+06E3 ARABIC SMALL LOW SEEN
```

ARABIC SMALL HIGH SEEN is included in MCM because most Quranic orthographies use the character as an MCM only. Orthographies that place the small seen differently will need to use a CGJ.

**Example 2a** [Al-Hilâlî]

```
١٠٥
```

**Example 2b** [Al-Hilâlî]

```
١٠٦
```

In Example 2a, the small high seen is rendered below the sukun, while in Example 2b, it is rendered over it. The examples are indeed from the same document (Al-Hilâlî and Khân 1996), just two pages away. The small high seen has different roles: in Example 2a it is a hint that the base letter, sad, should be pronounced as if it was a seen; in Example 2b, it is a pause-related hint.
Running AMTRA on this string does not result in any changes.

Example 2b (characters and properties):

Running AMTRA on the string in Example 2b resulted in an undesired change. It puts a sukun over a seen above. If an orthography needs to put the seen above over the sukun, the text should be encoded as <sukun, CGJ, seen above>.

In Example 3, AMTRA puts a shadda over a small high yeh.
If an orthography needs to put the small high yeh over the shadda, the text should be encoded as <shadda, CGJ, small high yeh>.

Running AMTRA on this string does not result in any changes.

**U+08F3 ARABIC SMALL HIGH WAW and U+08D3 ARABIC SMALL LOW WAW**

U+08F3 ARABIC SMALL HIGH WAW “is functionally similar to the already-encoded U+06E7 ARABIC SMALL HIGH YEH” and therefore small high waw is included in MCM [Pournader]. In available examples, small high waw and small low waw are functionally equivalent and, because they emphasize the vowel, are strongly bound to the body of the word. For these reasons they are both included in MCM.

**U+06E8 ARABIC SMALL HIGH NOON**

**Example 4a** [Quran2]

Example 4a has a sukun over a small high noon. AMTRA puts a sukun over a small high noon. If an orthography needs to put small high noon over sukun, the text should be encoded as <sukun, CGJ, small high noon>.

**Example 4b**

Example 4b shows a practical orthography that uses small high noon for nasalization. It is theoretically possible for a vowel to appear above the small high noon in this practical orthography. In such a case, AMTRA puts the vowel (in this case damma) above small high noon.
In order to force the small high noon above the vowel, use the CGJ (<oe, damma, CGJ, small high noon>).

U+08CE ARABIC LARGE ROUND DOT ABOVE and U+08CF ARABIC LARGE ROUND DOT BELOW

Example 5 [Quran3]

Example 5 has a fatha over a large round dot above. AMTRA puts a fatha over a large round dot above. If an orthography needs to put large round dot above over fatha, the text should be encoded as <fatha, CGJ, large round dot above>.

5 Supplemental Information

5.1 Use of NFD and Not NFC

NFD assures that sequences such as <superscript alef, madda> always result in the same ordering, independent of the base letter. If the algorithm were to use NFC instead, the sequence <alef, superscript alef, madda> would have resulted in a different order than <lam, superscript alef, madda>, because NFC composes <alef, madda> to <alef-with-madda-above>.

5.2 Shadda

The Canonical Combining Class for shadda (ccc=33) is higher than most vowels; however, it should be displayed closer to the base than the vowels.

5.3 Kasra and Kasra-like Characters

AMTRA is able to handle the special ligation of kasra and kasra-like characters which are ligated with a shadda or hamza in some styles and appear just below them instead of below the base letter; they still logically follow the shadda or hamza.

5.4 Rationale for Exclusion of Some Marks

Meem above (ccc=230), meem below (ccc=220) and other similar characters are not included in the MCM because their behavior already meets normal expectations. Examples 6a-6c show that the meem is
normally kept after fatha, kasra or damma, whereas including meem above and meem below in MCM would have the undesirable effect of moving them in front of fatha, kasra or damma.

Example 6a [Quran1] (page 11)

Example 6b [Quran1] (page 21)

Example 6c [Quran1] (page 19)

Sukun alternate forms

There are three sukun-like marks encoded at U+06DF..U+06E1 that are used in some Quranic orthographies to denote different entities – they may not always represent a sukun. The Canonical Combining Class of these marks is 230, so their ordering in the presence of other combining marks is not affected by AMTRA. However, since the combining class for the sukun is 34, these sukun-like marks will not be treated like a normal sukun in all cases. Users who create data using these alternate sukun characters will have more flexibility than when using the normal sukun. AMTRA does not make them equivalent to U+0652 ARABIC SUKUN, as that would make the algorithm unnecessarily complex and make the usage of CGJ more frequent.

Maddah

Neither U+0653 ARABIC MADDAH ABOVE (ccc=230) nor U+06E4 ARABIC SMALL HIGH MADDA (ccc=230) are MCM because they are normally displayed above vowel marks.

5.5 Dotted Circles

Some rendering engines will insert a dotted circle for what it understands to be an invalid sequence. This is a problem in Arabic script because something that appears invalid may actually be valid text in some lesser known orthography of a minority language or in the Quran. For example, the Microsoft Windows text rendering engine, described in [Microsoft], inserts a dotted circle in combinations of certain Quranic marks that are known to appear with each other in the Quran.

Such spell-checking processes are best implemented at a higher level than a rendering engine. Also, a dotted circle insertion algorithm that displays all canonically equivalent sequences identically is hard to design and the result may be counter-intuitive for its users.

Implementations of the algorithm may be adapted to insert dotted circles by applying the algorithm first and then inserting the dotted circles.

5.6 Other Uses for AMTRA

There is no intention or expectation that AMTRA would be applied to stored text. However, there may be situations unrelated to rendering where AMTRA may be useful, and this UTR does not prohibit such use.

As an example, when a text editor is processing a backspace key, a decision has to be made about what character(s) to remove from the text. For sequences involving combining marks, if the desire is to remove one mark at a time, users may have an expectation that the outermost marks should be removed first. For Arabic script the AMTRA could be used to identify outermost marks.
5.7 **Best Combining Classes**

Combining Marks in Arabic

When new combining marks are encoded, 220 should be used for below marks and 230 for above marks. In the special cases where an alternative version of the basic *tashkil* is encoded, the same **Canonical Combining Class** as the *tashkil* could be used, but extreme care should be taken.

5.8 **Workaround for Mistaken Canonical Combining Class Assignment**

**U+08D9 ARABIC SMALL LOW NOON WITH KASRA**

When it was added to Unicode 9.0, the *small low noon with kasra* (which appears below the text) was mistakenly given a ccc=230 (mark above). It should have been 220 (mark below), but that cannot now be changed. When used with other combining marks, there are a number of issues:

- When used with any ccc=220 (marks below), in the absence of any *combining grapheme joiner* characters, the reordering by AMTRA will always place the ccc=220 marks between the base character and the *small low noon with kasra*. If this is not desired then a *combining grapheme joiner* can be used to prevent the reordering.
- Combining class sequences containing both U+08D9 and another character of ccc=230 might have the same display but not be canonically equivalent. For this reason, and since it is likely pronounced last, it is recommended that U+08D9 be encoded at the very end of the combining mark sequence.
- Font developers should make sure that *small low noon with kasra* is treated as if it was a mark below and therefore has no impact on rendering of any marks above.

**References**


[Feedback] Reporting Errors and Requesting Information Online

https://www.unicode.org/reporting.html


[Microsoft] Microsoft Typography 2014. Developing OpenType Fonts for Arabic Script.


[Microsoft USE] Microsoft Typography 2017. Creating and supporting OpenType fonts for the Universal Shaping Engine.


[Reports] Unicode Technical Reports

https://www.unicode.org/reports/
For information on the status and development process for technical reports, and for a list of technical reports.

[Unicode] The Unicode Standard
For the latest version, see: https://www.unicode.org/versions/latest/

[Versions] Versions of the Unicode Standard
https://www.unicode.org/standard/versions/
For information on version numbering, and citing and referencing the Unicode Standard, the Unicode Character Database, and Unicode Technical Reports.

Modifications

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

Revision 7:

- Added discussion of the following characters:
  - U+08D9 ARABIC SMALL LOW NOON WITH KASRA
  - Small editorial changes in reference to “Canonical_Combining_Class”

Revision 6:

- Added the following characters in 3.1 Modifier Combining Marks (MCM) to the MCM:
  - U+08CA ARABIC SMALL HIGH FARSI YEH
  - U+08CB ARABIC SMALL HIGH YEH BARREE WITH TWO DOTS BELOW
  - U+08CD ARABIC SMALL HIGH ZAH
  - U+08CE ARABIC LARGE ROUND DOT ABOVE
  - U+08CF ARABIC LARGE ROUND DOT BELOW
  - U+08CE ARABIC LARGE ROUND DOT ABOVE and U+08CF ARABIC LARGE ROUND DOT BELOW
    - Added section.
- 5.4 Rationale for Exclusion of Some Marks
  - Renumbered examples from 5a-5c to 6a-6c.

Revision 5 being a proposed update, only modifications between revisions 4 and 6 are noted here.

Revision 4:

- Initial approved version.
- 3.1 Modifier Combining Marks (MCM)
  - Moved U+08D3 ARABIC SMALL LOW WAW above U+08F3.

Revision 3:

- Draft Technical Report
- Summary
  - Summary URL turned into a reference.
- Description of the Algorithm
  - Renamed section.
  - Removed Review Note and incorporated text into following paragraph.
- 3.1 Modifier Combining Marks (MCM)
  - Added U+08D3 ARABIC SMALL LOW WAW to MCM.
- 3.2 Specification of AMTRA
  - Renamed section.
- 4.3 Examples
- Removed reference to ARABIC NASALIZATION MARK.
- Changed self reference to [Pouraner] to a normal reference.
- Added rationale for including U+08D3 in MCM.

- **5.6 Other Uses for AMTRA**
  - Small editorial changes.

- **References**
  - Added Microsoft Typography 2017 link.

**Revision 2:**

- Converted to html.
- Renamed algorithm to have a more pronounceable acronym.
- **Title**
  - Renamed document.
- **Summary**
  - Clarified scope and intent of this UTR.
- **1. Overview**
  - Reworded the Overview for clarity.
- **3.1 Modifier Combining Marks (MCM)**
  - Reworded stability statements in final paragraph.
- **3.2 AMTRA**
  - Reworded steps 2b and 2c for clarity.
- **4.3 Examples**
  - Reworded paragraph in Example 3.
  - Added explanatory details and graphics for Examples 1, 3, 4a and 4b.
- **5.4 Rationale for Exclusion of Some Marks**
  - Reworded first paragraph.
- **5.6 Other Uses for AMTRA**
  - Clarified that there is no intention or expectation that AMTRA would be applied to stored text.
  - Expanded to indicate why a text editor may want to utilize AMTRA within backspace processing.

- **References**
  - Modified Microsoft Typography link.
  - Sorted per Unicode document conventions.

**Revision 1:**

- Initial Draft.