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Africa is home to a very large number of languages, with the figure of over 2000 often cited. Because of the large number of languages -- some of which may not have established orthographies – it is very difficult to verify that all the characters needed for African languages are included in ISO 10646.

The Latin script is used by most of the languages in sub-Saharan Africa and so is largely covered by ISO 10646. For languages outside of sub-Saharan Africa, the Arabic script is used, as well as other scripts, including Tifinagh and Ethiopic; these are presently also covered by ISO 10646. For each of these scripts a small number of additional characters are likely to be required in order to cover minority language needs. A few additional scripts have been identified as not yet being included in ISO 10646, for example, Loma and Kpelle. WG2 recently approved additions of character repertoire for the Ethiopic and Tifinagh scripts, and remains responsive to the needs of other minority language communities. It expects to see proposals for such characters (and scripts) in the future. The Script Encoding Initiative at UC Berkeley works with users and groups to identify and propose missing characters and scripts to WG2.

One useful method of identifying missing characters is by compiling locale data, as locale data can include a list of all the letters used by a particular language and codepoints to be used. Such a listing can therefore show whether a particular letter or symbol is missing. Progress on compiling such locale data for all the African languages is only beginning, however. Projects such as the Common Locale Data Project (http://cldr.unicode.org) make it possible to enter such data, and the SEI project encourages linguists and users to make submissions in order to help identify missing characters and scripts.

Attached is a paper presented at a conference in September 2008 on the situation regarding support on African languages in Unicode/ISO 10646, as well as in software and fonts. The paper touches on the challenges involved, and provides references to ongoing projects.

Support for Modern African Languages and Scripts in Unicode/ISO 10646: Where are We Today?

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I. Introduction

The encoding of scripts in Unicode/ISO 10646[1] and support for rendering of complex scripts has progressed rapidly over the last several years. Nine years ago, the only non-Latin scripts of Africa in Unicode were Arabic, Ethiopic, and Coptic. At the time, support for complex Latin orthographies was so uneven that there were some efforts to propose interim 8-bit standards.

Today, however, we can expect to be able to use most African language text on computers with little or no problem, using the latest operating systems, fonts, and software. The sample below was created on Vista with MS Word. The text, in Yoruba, comes from the title and opening lines of the Universal Declaration of Human Rights, off the UDHR in Unicode Project (which is hosted on the Unicode website). As you can see, the combining vertical line below are correctly placed, as are the combining diacritics.

ÌKÉDE KÁRÍAYÉ FÚN ÈTỌ́ ỌMỌNÌYÀN

ỌRỌ̀ ÀKÓSỌ

Bí ó ti jẹ́ pé ṣíṣe àkíyèsí iyì tó jẹ́ àbímọ́ fún ẹdá àti

(Universal Declaration of Human Rights in Yoruba from UDHR in Unicode project, http://www.unicode.org/udhr/)

However there are still issues that need addressing. This paper draws primarily on the work done by Don Osborn as part of his work on the Pan African Localisation project (http://www.panafril10n.org/). This paper also incorporates the results and perspectives of my project, the Script Encoding Initiative at UC Berkeley (http://linguistics.berkeley.edu/sei), which works to be sure scripts and characters not yet in Unicode are proposed, and to ensure locale data are submitted to CLDR. The third collaborator, Shigeaki KODAMA, works on the Language Observatory Project (http://www.language-observatory.org), one of whose goals is to assess the presence of languages on the Internet. Its larger purpose is to encourage the support and processing of those languages that may be "falling through the Net." The research results of Shigeaki KODAMA are also included in this presentation.

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[1] In this paper "Unicode" is being used as a shorthand for "Unicode/ISO 10646."

This paper seeks to give a quick survey of the current situation for support for African language scripts and orthographies, and will extend into topics discussed elsewhere at this conference, namely internationalization and localization.

II. Background

According to *Ethnologue* (Gordon 2005), Africa has over 2000 languages.[2], making it one of the most multilingual continents. At the same time, the linguistic map is complex, with many language groups interspersed and borders, inherited from partition of the continent during colonial times, dividing communities The sociolinguistic situation is often complicated as well. So generalizations must be made cautiously.

The writing of African languages is in most cases historically recent (within the past 175 years), with most African cultures being described as having "oral traditions." Apart from Arabic in the north and a limited amount of use of the Arabic script for languages in the Sahel and Swahili (mainly historical), the Ethiopic abugida in the Horn of Africa, and a few less widely used scripts, most writing of African languages uses the Latin script[3].

Many languages, especially less widely spoken ones, do not have a set orthography. According to UNESCO, approximately 80% of African languages do not have an established orthography (Osborn 2007b). Needless to say, this makes for difficulties in creating keyboards, developing spell-checkers, etc.

According to the *Ethnologue* (Gordon 2005), Africa has 2,092 languages, nearly as many languages as Asia (2,269 languages), yet has far fewer speakers (Africa 675M speakers, Asia 3.4B speakers). Africa also has shorter writing traditions, and less support in language policy and planning. Localization in Africa is not at the level of Asia, with the exception of Arabic in the north and the situation in South Africa, which are more advanced. (Osborn 2007a).

Another feature of the language situation in Africa involves the role played by the colonial powers. Not only did they leave a continent with most language groups split across borders, but an overlay of several European languages act as official or semi-official languages in all states. While the European languages can facilitate communication across the continent, they also serve to add a new set of linguistic divisions. Hence, the linguistic situation is a complex, multilingual one in which Africans must master several languages for use in different contexts. (Osborn 2007a)

The dual processes of internationalization and localization of ICT are still felt incompletely and unevenly in Africa, and its languages have not benefited directly from them as much as it might. This is due to largely to low connectivity and lack of access, but also to a range of other factors, from old computers, to lack of understanding of Unicode even among computer experts, to attitudes about language.

II. African Writing Systems

Writing systems for Africa might be grouped in three headings:
1. Ancient African writing systems that developed with a language or family of languages. These include Ethiopic and Tifinagh, which are used today for modern languages, as well as a number of purely historic scripts, such as Egyptian hieroglyphs and Coptic (which is

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[2] Even more conservative estimates are quite high. (It is important to note that "languages" can be counted different ways.)

[3] A map from http://www.nationmaster.com/encyclopedia/Latin-alphabet roughly indicates the location of where Latin is used.

      used liturgically). African cultures also used various forms of graphic symbolism (Mafundikwa 2004), but not systematically for writing a language.

2. Writing systems invented in historically recent times (within the last 2 centuries). A few of these, like N'Ko and Vai, are in ongoing use; others are not, such as Bagam (which was used in the Cameroon) (Tuchscherer 2007)

3. Adaptation of another script for writing languages. Probably the first example of this on any widespread basis was the use of Arabic script for non-Arabic African languages by learned Muslims. However, by far the most important introduced script in most of Africa is Latin.

The adaptation of the Latin and Arabic scripts to represent the phonologies (sound systems) of African languages, has often involved use of modified letters (extended characters) and various diacritics, and this is especially true for the languages of western and central Africa. In the case of extended Latin characters, many are in the International Phonetic Alphabet (IPA). The modifications made in the Latin script for African languages were often made by missionary groups, according to systems that made sense to them at the time. Over time, efforts have been made to standardize Latin-based orthographies for the major languages and within many countries. The effort to harmonize the rules of transcription among countries began in the colonial period and was aided by a number of conferences sponsored by UNESCO in the 1960s and 1970s.

      The systems of transcription used for the use of the Arabic script for non-Arabic languages have no formal standards and only varying local customization of orthographic rules. Latin transcriptions have tended to replace the use of Arabic (such as for Swahili and Hausa), but the Arabic script (for non-Arabic languages) still are used in some areas.

A. Latin-based orthographies

Before Unicode became the de facto international standard for handling text in ICT [information and communication technology], Charles Taylor proposed a typology of African orthographies in a book on *Typesetting in African Languages* (Taylor 2000). The following schema is similar, although it focuses only on Latin-based scripts and takes into account the new realities of Unicode. (These categories over-simplify the situation somewhat, but the point here is to show that each set of categories has its own issues.[4])

- Category 1 orthographies: ASCII - all characters and combinations covered by the ASCII character set. African examples: Swahili, Zulu. There are no issues for fonts or input, since these are ASCII only.
- Category 2 orthographies: Latin-1, meaning all characters and combinations covered by characters in ISO/IEC 8859-1 or Windows 1252 (also called "extended ASCII"). African example: Sango. There may be issues here, particularly if users have old computers (or users are not familiar with input of accents in a keyboard layout or the keyboard layout does not support them).

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[4] Categories 1 and 2 are similar to what Taylor presented; categories 3 and 4 are approximately the same as his categories 4 and 3, respectively; and Taylor used category 5 for non-Latin scripts, some of which are supported by Unicode, and which are treated here separately.

- Category 3 orthographies: Extended-Latin with no combining diacritics, meaning that the orthographies are covered by the Latin ranges of Unicode without need to support combining diacritics. Here there may be issues with systems for input and available fonts. African examples: Fula, Gikuyu.
- Category 4 orthographies: Latin as complex script, meaning the orthographies are covered by Extended-Latin with use of combining diacritics. Here there are issues with input, fonts and rendering that are not encountered in the above. African examples: Yoruba, Igbo.
- Category 5 orthographies: Orthographies not fully supported by Unicode, which at this point would mean a missing character (the number of orthographies falling in this category are probably very few). Because characters are not in Unicode, this category could also be problematic for input, fonts and rendering.

As part of this system, each higher level may incorporate some aspects of the levels below. Wolof, for instance, is a category 3 orthography due to use of the letter eng for the velar nasal n, but also has a number of accented characters from Latin one (category 2).
Usage may vary between the different categories: In Bambara, for instance, tone marks are generally not used, so it is for most purposes a category 3 orthography. However, if tones are used over the open e and open o, one encounters the same rendering issues of a category 4 orthography.

Since there was no ISO 8859 standard for any African language (ISO 6438 was a bibliographic standard, and not wide-scale computing) and fonts in the 1990s could not adequately handle diacritic stacking and diacritics on extended characters for African orthographies, alternatives were explored by different groups. For example, in the mid-1990s the African Language Resource Council (a joint project of the African Studies Center and the Linguistic Data Consortium at the University of Pennsylvania) considered the idea of creating an 8-bit "quasi-standard" solution for extended Latin in Africa, as well as adding more precomposed characters to Unicode. Eventually, ALRC abandoned its effort, because the technology to support combining diacritics improved.

B. Arabic-based orthographies
Besides the use for the Arabic language, the Arabic script is also used for non-Arabic languages in Africa located south of the Sahara. There is a long tradition of using Arabic to write African languages, extending back at least unto the 16c in the libraries and centers of learning in Timbutku.[5] The modified form of Arabic for non-Arabic languages in Africa is called "Ajami." It is used across a wide swath of countries, from Senegal and Gambia to Tanzania and Kenya. Efforts to standardize Ajami by the Islamic Education, Scientific and Cultural Organization ISESCO, have not been successful since it seemed to have been influenced by Farsi and Urdu usage (Fallou Ngam, p.c.). In general, south of the Sahara states tended to focus on Latin-based orthographies, and not much has been done with Ajami transcriptions, other than to sponsor some studies (Osborn, p.c.).

C. Non Latin/Arabic scripts
Unicode currently includes 5 "modern" African scripts – that is, scripts used for modern languages: Ethiopic, Tifinagh, Vai, N'Ko, and Osmanya (though the latter is not the official

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[5] Fallou Ngam, "Ajami Scripts in the Senegalese Speech Community", powerpoint presentation.

script for Somali today). Of historic scripts originating in Africa, Coptic is in Unicode (and a few characters for Old Nubian are contained in the same codeblock).

A number of other scripts are in the standards process now, including historic and modern Bamum, Egyptian hieroglyphs (Gardiner set plus supplements), and Meroitic, a historic script dating to the third century BCE. These are all being proposed via my project at UC Berkeley.

Work on various other scripts is either underway or planned. These include at least 5 scripts. Most of these scripts are in use today, though Kpelle and Loma aren't actively used. There is some interest in reviving Loma.

Besides entire scripts, a number of characters are known to be missing from Unicode from already encoded scripts. SIL is working on Arabic and Ethiopic additions needed for modern African languages.

The following historic scripts are still not yet in Unicode: Masaba, Wolof, Hausa (includes 3 scripts), Fula (includes 2 scripts), Bété, Bagam, and Mandombe. Many of these are on the workplan for future work by the Script Encoding Initative, pending funding.

While it is true Latin-based orthographies predominate in writing African languages, those scripts that originated in Africa are a matter of special pride that Latin-based or Arabic-based scripts do not.

The N'Ko script, for example, was devised by Solomana Kante in 1949. It is used for the Mande group of languages in West Africa, has spread beyond Guinea and Ivory Coast into the surrounding countries of Mali, Senegal, Liberia, Burkina Faso, and Sierra Leone (Tuchscherer 2007 and Doumbouya, p.c.). Many publications, including newspapers and books have been published in N'Ko, and continue to do so. An expatriate in Philadelphia has driven the effort to get N'Ko into Unicode and, more recently, to get rendering engine support for N'Ko.

It is possible that other non-Latin scripts might also become more widely used, like N'Ko has done. The Bamum script in Cameroon, for example, is currently deemed an "endangered" script: there is only one user for whom it is the only means of writing, though the script appears in art and signs. Still, the script represents a powerful symbol of the Bamum cultural achievement – the creation of an original script-- though it is true few people actually can read it. Nevertheless, it is undergoing a revival effort (with support from Bamum Scripts and Archives Project), with teaching of the script continuing. It is hoped the script's use may become more widespread. This may be the case for other non-Latin (/Arabic) scripts as well.

IV. Unicode support
Latin orthographies
Unicode support is good for categories 1, 2, and 3, but there are issues with category 4 Latin orthographies -- those orthographies using Extended-Latin and combining diacritics. One of the biggest issues is diacritic placement. Even though OpenType has vastly improved the situation, the fact that many users are using older systems means they aren't getting the expected result when typing or viewing text.

Arabic orthographies: Ajami
Because there is little in the way of standardized forms of Arabic used for African languages, it is difficult to judge the level of support fully.
Non-Latin/Arabic scripts
Five "new" African scripts have appeared over the past 9 years. Unicode 3.0 had Ethiopic (with additional extensions in 4.1), 4.0 had Osmanya, 4.1 had Tifinagh, 5.0 had N'Ko and 5.1

included Vai. A quick survey finds Unicode fonts available for all of these, though Vai is still only included in a few fonts (James Kass' Code2000 and one by Jason Glavy). However, font availability does not give the full picture of the situation for level of support for these scripts.

I want to focus on one script in particular, N'Ko, as I have been working with the user community and can relay the types of issues that have arisen.

Of all the five newly approved African scripts, only N'Ko is right-to-left, and this has been the source of problems. This is particularly unfortunate, given that "the production of published literature in N'Ko probably exceeds the published literature in all the other West African scripts combined" (Tuchscherer 2007). N'Ko has suffered because it is not currently supported in Vista's Uniscribe rendering engine, and Windows is the predominant platform used by the N'Ko community. An alternative to Uniscribe, SIL's Graphite rendering engine, has been used in the meantime. Unfortunately, there have been several difficulties in getting Graphite to handle right-to-left correctly, but most problems have finally been rectified. Now I am told that the latest version of OpenOffice using Graphite still has poor letter and accent alignment for N'Ko; a new version of Graphite in OpenOffice, currently being beta-tested, will hopefully solve the outstanding issues.

Nevertheless, this doesn't address the larger issue: most N'ko users run Windows. The effort to get N'Ko into Uniscribe has involved trying to get government officials in Guinea to send in letters of support to Microsoft, requesting N'Ko will be included in the next version of Uniscribe. Unfortunately, just as the person spearheading the effort had lined up government officials in Guinea to send in letters, the president fired the officials, so the process must start anew. Despite this set-back, N'Ko is being taught in more village classes and schools in West Africa (and now two classes in Philadelphia). The case of N'Ko is emblematic of some problems faced by minority groups, who don't have the economic or business pull to get software support for their script. Still, I hope that in the near future N'Ko will finally be included in Uniscribe.

Shigeaki KODAMA, a researcher at Nagaoka University of Technology in Japan (working with the Language Observatory Project), surveyed 48 country code top-level domains, and discovered that webpages containing only African languages numbered only 2.3% of the total webpages in 2006, and in a smaller sampling in 2007, only 1.2%. (KODAMA forthcoming).

While the African languages are scarce in webpages, the colonial languages, such as English and French, predominate: they make up about 70 – 77% of the webpages in Africa.

According to a paper by a RIFAL study on African webpages published in 2003[6], African languages are found on the Web more as topics of study than as the means of communication; English predominates – even in Francophone areas - as the language of communication; African language courses are rare on the Web (Fantognan 2005).

Though the World Summit on Information Society's "Plan of Action" document, created in Geneva in 2003 (http://www.itu.int/wsis/docs/geneva/official/poa.html), repeated the need to develop local content, particularly in indigenous languages, it is clear that the development of local content on the Web in African languages is still in its infancy. The goal of preserving the world's cultural and linguistic diversity on the Web and elsewhere has still a long way to go.

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[6] *Cahiers du RIFAL* [Réseau international francophone d'aménagement linguistique] Nov. 2003 #23, "Le traitement informatique des langues africaines"; article "Les langues africaines sur la Toile," by Marcel Diki-Kidiri and Edema Atibakwa Baboya.

Problems
The low amount of content on the Web in African languages is hardly due solely to support for the language in rendering engines, fonts, and keyboards, but is intertwined with much larger factors, mentioned earlier in this presentation, including:
- o access (to computers and software and a reliable internet connections),
- o basic literacy in language(s);
- o computer training and education
- o governmental or institutional support.

Locale data collection for African languages
The CLDR project has locale data on 38 different African languages. Vista has about 12 locales (not including English or Arabic; 5 are in South Africa). With over 2000 languages in Africa, much work remains to be done.

My project at UC Berkeley has tried to reach out to linguists, to encourage them to submit locale data. Two requests have come forward and I am trying to focus on these in the coming year:
- First, provide the capability of entering locale data by hand or offline; this is particularly true if electricity/internet connection is unreliable. An attendant problem will be how to accurately have this information transmitted and entered into CLDR. This will have to be considered carefully.
- Secondly, a "barebones" list of the core information on languages and scripts needed for CLDR.

Fulfilling these two requests could help encourage more users to submit data.

Localization Trends
In general localization has been centered on content (web-content), with some discussion of keyboards and a little software localization. On the whole, localization is more advanced in North Africa where Arabic is well advanced, South Africa, and countries using Swahili in the East (Mozambique, Tanzania, Kenya, Somalia, Democratic Republic of the Congo, Uganda, and Rwanda).

Localization has been fostered by development groups, such as One Laptop Per Child and the Canadian based International Development Research Centre, with some modest local interest and a few commercial projects. Work is done by Africans in Africa, Africans abroad, and non-Africans. The primary commercial interest is Microsoft, which signed agreements to develop Language Interface Packs. Some mobile phone companies have been working on text messaging capacities for their products, such as Nokia did.

The following summary reflects some of the ongoing localization trends in the regions of Africa. In sum: work is often being done on localization via OpenSource projects; some corporate interest in locales, particularly by MS, and participation by development groups, as One Laptop Per Child.[7]
North Africa:
- Has seen benefits from advances in Arabic computing (Egypt has been a leader as have some international software companies)

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[7] The summary below dates to the situation in September 2008, and has likely changed.

- OpenSource software groups have been active in Egypt and Morocco
- Tifinagh was approved and Morocco has included teaching of the script in school

West Africa:

- Nigeria
    - Focus has been on keyboards; Nigerian Information Technology Development Agency has proposed a standard; "Konyin" keyboard for multilingual keyboard for Africa
    - Hausa localization of OpenOffice.org
    - Microsoft has locales for: Hausa, Yoruba, Igbo
    - Yoruba speech recognition project by ALT-I
    - Text to speech project for Ibibio
    - One Laptop Per Child includes Hausa, Yoruba, and Igbo
- Burkina Faso: Openoffice.org early stages for Bambara (Jula), Moore, Fulfulde; keyboards
- Senegal: Microsoft agreement on Wolof
- Ghana: Kasahorow online dictionary and sort/order info for various orthographies; plans for Openoffice localization
- N'Ko encoded in Unicode

Central Africa:

- Central African Republic: web content for Sango; software planning (OpenOffice.org)
- Cameroon: experiments with online language instruction modules
- Congo and Democratic Republic of Congo
    - Planning and discussions
    - Content: some in Lingala, including on some email lists

South Africa:

- Translate.org has localized OpenOffice.org in all 11 official South African languages; created fonts, keyboards, and spell-checkers
- Cellphone localization (with impetus from companies, notably Nokia), predictive text (means of facilitating input of text using cellphone keypad)
- Microsoft has locales for Afrikaans, Sesotho sa Leboa, Setswana, Wolof, Xhosa, Zulu.
- Text-to-speech in Tswana, Zulu, and Afrikaans
- Talk about assisting other countries

East Africa:

- Ethiopia
    - Current OpenOffice.org project for Amharic (works on Windows, but not Linux)
    - Issue of standardizing keyboards not yet settled; government completed stnd. was rejected by MS
    - Amharic mobile phone released by Nokia, input not ideal (but mobile service is now turned over to a Chinese company, ZTE, which purportedly won't support non-ZTE cell phones)
    - One Laptop Per Child with Amharic delivered in 2008, but includes sub-optimal keyboard
    - Nyala font included in Vista with Ethiopic characters from Unicode 3.0 and 4.1 additions, Amharic keyboard (but keyboard "not ideal"), clock, and Georgian calendar

- Eritrea
    - Some groups planning on work on Tigrinya
- Tanzania: KiLinux localization of Openoffice.org in Swahili
- Uganda: translation of Mozilla Firefox browser into Lugunda; other projects planned
- Kenya: Swahili text-to-speech project; MS has locale for Swahili
- Rwanda: MS has locale for Kinyarwanda; OpenOffice.org Kinyarwanda project is ongoing
- Madagascar: FOSS efforts underway

IV. Conclusion

This paper has presented only an overview of the nature of the progress – and challenges— involving Unicode support for modern African languages and scripts, as well as issues of localization and internationalization. As is evident, the continent presents a complex linguistic situation, made more difficult because of economic, social, and infrastructural factors.

In terms of Unicode support, Latin-based orthographies are generally already covered by the Unicode Standard. While fonts and software support for the orthographies is fairly good on the latest operating systems, support tends to be sub-optimal on older computers, which are often what is available for the user communities. Work continues apace on new scripts, but this process can be slow, as it takes time to locate experts and get feedback.

The open-source movement has been especially beneficial in encouraging development that supports African languages. Localization has relied heavily on volunteer effort; most governments and donors have not paid much attention. Increased support from governments, donors, and industry would be very beneficial in helping to pick up the pace of development.

A number of outstanding issues remain. Many orthographies of African languages still need to be standardized. Such a standardization effort should ideally not be a country-specific project; orthographic standardization should be done while considering the orthographies of neighboring countries and related languages of the region. While this is properly the field of applied linguistics, it impacts computer technology, especially localization. Another issue is keyboards. The availability of Keyman and Microsoft Keyboard Layout Creator has spawned an increasing number of keyboard layouts. While this serves to fulfill the local need, it also causes duplication of effort for the community as a whole. A government supported standard for the keyboard might help.

In sum, the Unicode Standard/ISO 10646 and localization have offered critical basic means for the building of new content for languages in Africa, but more work needs to be done to take advantage of this.

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