Hello World - Ney Yibeogo: What Needs To Be Achieved for a Truly Inclusive World Wide Web

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ABSTRACT
The World Wide Web is a crucial open public space for information, communication and knowledge sharing for billions on the planet. Yet, it is not accessible for over half of the world population, mostly in the Global South. To overcome this digital divide, policies are promoted to improve global access to the Web and its resources, such as "affordable internet". A different perspective emerges when thinking not inside-out from the Global North, but from the other side of the digital divide acknowledging today's realities, contexts and needs on the ground in e.g. Africa. Obstacles such as scarce electricity, no internet, poor infrastructures, and limited text literacy are here to stay for many years to come. Yet, social communication networks are massive, also in the remote rural areas in the Global South, but they are centered on speech in the local languages, and with radio and especially mobile phone as major channels. If the Web is to become *truly* inclusive, it is in need of *Web extensions* – also outside the Web proper – that reach out to different types of already existing social communication networks and, specifically, cater for speech and voice services in many local languages that are now unsupported. Illustrated by cases and deployments from our field research in rural West Africa, we outline how small but concrete steps towards such Web extensions can be made.

Categories and Subject Descriptors
Information Systems – World Wide Web – Web Applications – Social Networks

General Terms: Web access, literacy, divides, development.

Keywords: Connecting the unconnected, Inclusiveness, Voice Services, Languages, Africa, Web extensions.

1. CONNECTING THE UNCONNECTED
The World Wide Web is a crucial, open and public, space for information, communication and knowledge sharing for billions on the planet. However, it is not yet accessible for over half of the world population, most of them in the Global South. This phenomenon is often termed the *digital divide* [8]. The (much more than a) Web Science research question is what one may do about it [1]: how to connect the unconnected?

The present paper addresses this question from a slightly uncommon perspective. Let us accept (for the time being, for the sake of argument) the somewhat simplistic metaphor of the "digital divide". The question how to bridge the extant gap of the digital divide can then be approached from two different sides. First, one may take the view from the western or Global North towards those who are now excluded in the Global South – and as a result, what needs to be achieved following this line of thinking. This often encountered perspective triggers Web accessibility policies and strategies including advocacy for affordable internet, net neutrality, rights to and equality in digital opportunities [16].

Alternatively, one can think the other way around: starting from the Global South, from what current realities are on the ground, and subsequently consider what should be achieved in the realm of the Web, based on investigating local people's needs and priorities in the Global South. This paper takes the latter perspective, and thus arrives at some other important conclusions.

2. RADIO CITIZEN JOURNALISM (MALI – BAMBARA)
Many millions in the rural regions in Mali have mobile phones, but suffer from lack of electricity, no internet, poor infrastructures, and limited text literacy [13,14]. Apart from mobile telephony, and in the absence of TV and internet, community radio stations play an important role as information and communication hubs in rural regions of Africa. In Mali there are more than 200 small radio stations spread all over the country. These radio stations broadcast music (Mali is rightfully famous for its music tradition), but also local news and other informative programs for local listeners in African languages.

2.1 Foroba Blon system for village reporting
We briefly describe here the case of Radio Sikidolo, a small radio station in Konobougou, a village in the south of Mali several

hours from the Malian capital Bamako. It reaches up to 80,000 listeners in the region. According to its director, Adama Tessougué, this radio works with free-lance village reporters who collect news and announcements in the surrounding villages for broadcasting. Example topics are wedding announcements, funerals, lost animals, interviews and interesting stories. In the absence of internet in these remote areas, village reporters use simple GSM mobile phones to send news to the radio. For this, the program maker at the radio station had to be available in person on the phone, and then write down the incoming information on paper for broadcasting. Evidently, this task is time consuming and inefficient.

At Radio Sikidolo's request, our team of Web developers developed a voice-based system allowing village reporters to phone in and submit spoken news items that are stored offline in the system [13]. Messages can then be accessed and managed by the radio journalist through a web interface on his laptop, without the need for internet. The name of the system is *Foroba Blon*: this Bambara name refers to the Malian village square where everyone is allowed to speak out, though respectfully.

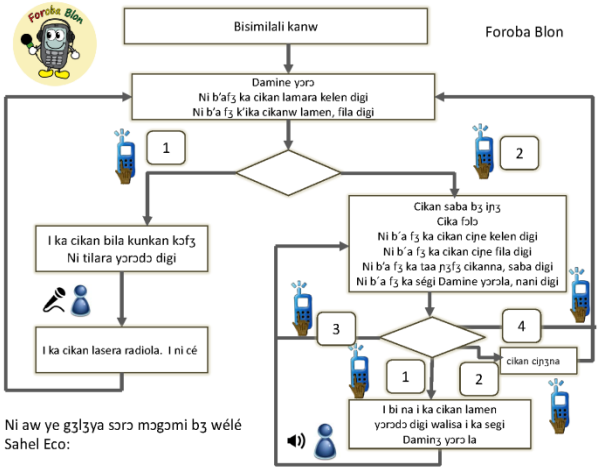

Figure 1. Foroba Blon call flow in Bambara.

In its first version [13], the Foroba Blon mobile voice interface was in French. The current, new, second version has a voice interface (Figure 1) in the local language Bambara: a common language spoken by about 15 million people in Mali, and the language spoken by most of the radio station listeners (we note that most of them do not even speak French, although it is the official national language). The new voice interface was built in close collaboration with the local radio journalists, to make sure the dialogue (Figure 1) was properly translated into Bambara.

The requirements of the Foroba Blon system were the result of an iterative and collaborative development process between developers and end-users [3]. This included: (i) a user-friendly easy mobile voice-interface; (ii) local Bambara language dialogues; (iii) robustness of hardware to survive dust and heat; (iv) robust software that can recover after commonly occurring power outages; (v) low cost for end users; (vi) a user-friendly web interface for the radio journalist, so incoming messages can be edited or removed, and meta-data can be added.

Other community radio stations have expressed their interest to have this system. Future work will be to scale up the current system and make the radio servers able to connect to each other and exchange information – even without internet connection.

2.2 Downscaling the web cloud

The current new, second, version of the Foroba Blon system has two big advantages. As discussed, it now has a voice interface in Bambara, the language spoken by most of the radio listeners. A second important step forward is that it now runs on a small, inexpensive server called Kasadaka (Figure 2), which is hosted locally at the radio station's premises and does not need any internet connection. The server has a local area network but also allows phone access via the (2G, 3G) phone network.

It is noteworthy that the initial version of Foroba Blon (that won the News Innovation Contest Prize of the International Press Institute) successfully ran on a voice service platform of a big multinational telecoms operator [13]. However, this platform – although marketed as open source – was closed down unilaterally by this corporation. This triggered our research for alternative (but simple, cheap, robust, "down-scaled" [10]) voice service hosting solutions.

Figure 2. Adama Tessougué of Radio Sikidolo shows the Kasadaka box on which the Foroba Blon voice service now runs with its Bambara language interface.

The solution we have developed, "Kasadaka" (which roughly translates to "Talking Box"' in a number of Ghanaian languages), is a low-resource computing platform. Its hardware is based on cheap and easy to replace components (such as RaspberryPi and GSM dongles) and its Open Source software components allow for rapid development of information services with multi-modal and multi-channel interfaces including GSM-accessible voice interfaces. Kasadaka uses Semantic Web technologies specialized for information storage and low-connectivity exchange [15]. Kasadaka's architecture enables rapid prototyping and adaptation of information services. Foroba Blon is one of several applications currently under development in West Africa.

3. METEO DATA SERVICES FOR LOCAL FARMERS (BURKINA FASO – MOORÉ)

3.1 Rainy season information needs

Many farmers and families in Burkina Faso depend on rain-fed agriculture. The rainy season is short (three months) and so pertinent information on actual and forecast rainfall is extremely important, for example, to better plan cropping calendars and improve harvests, but also to be alerted in time for emergencies such as floods and thunderstorms.

During recent collaborative use-case and requirements workshops in Gourcy, Burkina Faso, organized by NGO Réseau MARP, regional radio stations, the association of innovative farmers in the Yatenga province, and the W4RA team of authors, it became abundantly clear that important weather information never reaches local farmers in Burkina Faso. Global meteo information is in principle available through the Web, but it is not accessible to farmers that face the familiar issues of lack of electricity, of digital infrastructures, and issues of language and literacy.

A compounding problem is that global meteo information is rather coarse-grained, as the network of local weather stations is sparse. Several farmers are collecting their own local data (Figure 3), but there is a *disconnect* between local and global data, which is detrimental to the overall quality of forecasts.

Figure 3. Rain gauge on the land of innovative Burkinabe farmer Oussény Zoromé (right) in the village Somyaga (near the Yatenga province capital city Ouahigouya).

3.2 Weather, Web, ICT

One result of the mentioned workshops is the diagram of the process of production and diffusion of local farmer-relevant meteo data, as shown in Figure 4. The workshops made clear that there is a real big need by farmers for weather information, however, first of all via mobile services (simple feature phones) and spoken in the local language, in this case Mooré, a common language in Burkina Faso spoken by about 5 million people.

It is also seen from the workshop Figure 4 that there are many opportunities (annotated by numbers) for farmer-useful ICT support in the production and diffusion process of weather data. One recurring ICT/Web challenge here turns out to be how one can transform textual and visual data (as a natural form for much weather info) into crisp understandable voice messages in the local languages, and vice versa. This is a great challenge [2] as there are no Text-To-Speech (TTS) modules available for Mooré (and the same for Bambara and many other African languages) – even as they, with a multi-million speaker base, cannot even be called small languages. TTS systems for a language comprise a major effort: order many hundreds of millions of dollars/Euros [2], even if languages have a written version which is not always the case – the one for Bambara is quite recent. Thus, alternative, simpler and faster, methods are called for that can fulfill the need for voice-based Web extensions.

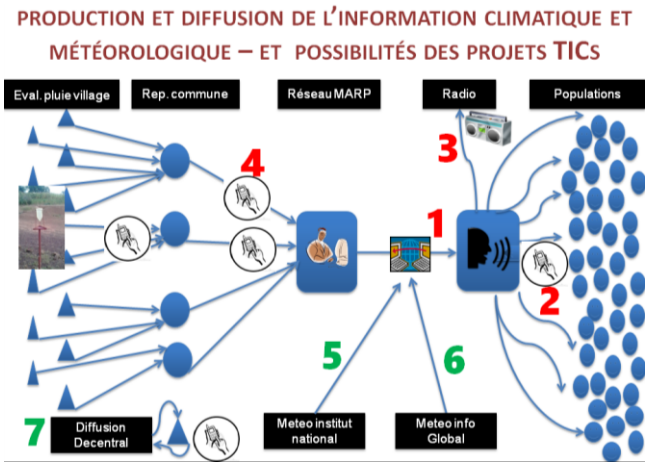

Figure 4. Workshop sketch of the process of farmer-relevant meteo data production and diffusion, annotated with (numbered) opportunities for useful ICT support.

3.3 "Ney Yibeogo": voice services in underresourced languages

In the Global North the 'traditional' voice-based services commonly used in customer service call centers, are starting to be replaced by smartphone apps, chatbots (through websites and platforms such as WhatsApp and Telegram) and voice assistants (Apple's Siri, Google Now, Amazon Alexa). These systems often rely on technologies such as Natural Language Processing (NLP), Automatic Speech Recognition (ASR) and sophisticated TTS systems (all running on powerful cloud-based platforms), which are combined to provide a 'natural' interaction experience to the end user [12]. These technologies might become a solution in extending the Web to reach the large African illiterate population.

Whereas these advanced technologies allow the development of human-like voice interfaces, today's global reality is one of excluded access to such services for the large populations living in areas without adequate internet infrastructure, since they are *cloud-hosted*. Moreover, underlying techniques such as TTS, ASR and NLP [12,2] are only available for a limited set of well-supported languages, excluding many African languages such as Bambara and Mooré.

In order to develop Web-like voice-based information services for the African population, it is necessary to go for simpler solutions to the problem of converting text and data to speech in local (unsupported and underresourced) languages. One solution to this problem used in the KasaDaka platform is a variant of the *slot-and-filler* method [2,13]. This involves splitting up sentences into reusable fragments which are recorded and stored. When text needs to be 'spoken' to a user, the system plays back the relevant fragments in the correct order. In this way a sentence is formed by concatenation out of pre-recorded fragments, allowing for dynamic generation of sentences.

The implementation of this method that is currently successfully used, works by dividing all speech that is required for a voice service (dialogues, questions, relevant subjects/objects, etc.) into fragments (cf. Table 1). These fragments are usually first written in English or French, after which they are translated to the language in which the system will be implemented. When the translation to all required languages is complete, the fragments are read aloud while being recorded. The fragments are then copied to the system. When a user places a call, the system dynamically

generates a dialogue document (in VoiceXML, see https://www.w3.org/TR/voicexml21/) by concatenating the voice fragments (in the correct language), which are then played back to the user in the order specified by the document.

Table 1. Example of voice fragments in the Meteo use-case.

Filename	English	Mooré
welcome.wav	Welcome to the KasaDaka Meteo service!	Ney waongo saasa kibay tuum noora zugu
select-days.wav	Please enter the number of days in the past of which you want to hear the rainfall data, the maximum is 9 days	Tôk y rasem soor yâmb sen dat n gelge saasa kibay sen looge rasema way pugê
mmOfRain.wav	Millimeters of rain	Saaga milimètra sôore
tuesday.wav	Tuesday	Talaata

This is a relatively low-tech solution but one of the few feasible under the circumstances. It allows for the creation of voice services in any language for limited domains, but as we have experienced, this goes a long way for many useful applications. Evidently, in the slot-and-filler approach, the real work resides in the recording and composition of fragments. The size of the set of fragments limits the domain applicability and the range of differing sentences that can be generated. If the functionalities of a voice service are to be expanded or changed, it is almost certainly necessary to create and record additional fragments.

One challenging aspect is the translation of fragments into the local language. This is no trivial task, as some of the concepts that are used in European languages do not necessarily exist as such in African languages. An example of this, which appeared in the rainfall use-case, is the notion of "municipality". While this is a normal concept in languages like Dutch, English and French, it turned out to be very hard to translate into Mooré. The reason is that municipalities are defined according to the French administrative system dating back to colonial times. But, this is a poor match to the rural notion of "place" of farmers that applies to getting local farmer-useful weather data in Burkina Faso.

In order to take the TTS slot-and-filler method used by the system out of the realm of magic (as it was perceived by many Burkinabe at the workshop), significant time was spent to explain this concept to the Burkinabe farmers and radio journalists. Through the classic "*Hello world!*" example (in Mooré: "*Ney Yibeogo!*") the generation of speech was explained: splitting the phrase up into two fragments: 'Ney' and 'Yibeogo', which then are stored in the 'dictionary' of the computer. To speak the phrase, the computer looks up the fragments from the dictionary, and combines them to form a sentence.

After explaining the concept, radio presenters worked together with the W4RA author team in translating and recording the fragments for the rainfall use-case. Resulting recordings were processed into corresponding audio fragments and implemented into the system. The following morning the service was demonstrated to the workshop (Figure 5), proving that this method allows for the rapid (even overnight) prototyping of support for (unsupported, underresourced) languages to a voice service.

Figure 5. VU Amsterdam master student André Baart shows an overnight demo version of the Mooré language voice interface to Burkinabe radio journalists and farmers.

4. WEB EXTENSIONS: MAKING EVERYONE'S VOICE HEARD

In the Sahel, there is a big need for information dissemination and knowledge sharing among smallholder farmers and families in remote rural villages. Important are, *e.g.*, the weather (particularly in the brief rainy season), community news and information, or useful methods for local agriculture (agro-ecology [5], Regreening [9]) to mitigate climate change and improve food security.

The World Wide Web is potentially very valuable, but many obstacles are standing in the way of realizing this potential: lack of electricity and internet/Web in the rural areas, low literacy, large distances, and poor infrastructures. The starting point to address this is an understanding that existing non-Web social communication networks are massive, also in the remote rural areas in the Global South, but they are centered on speech in the local languages, with radio and especially mobile phone as major channels. This is a reality (a very much socio-technical one [11]), and a major reason to think from the *other* side of the digital divide, with important reach-out implications that the Web and Web Science research has to come to terms with.

As we emphasized, there is a big difference between thinking about these issues from what is foremost a Global North perspective, versus taking the realities and needs of the South as the starting point. It points to different priorities for needed technologies, but more strongly, it leads to contrasting models of change: externally imposed, exogenous ones versus endogenous ones. This is a fundamental difference of approach not only in ICT(4D): compare the Great Green Wall idea (massive planting of trees) to improve the Sahellian conditions versus endogenous approaches such as agro-ecology and Regreening [9]. We furthermore believe a local community-centric endogenous approach is crucial in improving the much debated ICT4D projects *sustainability* [4].

From West Africa we discussed several real-world use cases and we indicated some practical strategies how one can deal with Global South realities in ways that avoid common Global North assumptions and misunderstandings. Although full-blown support of languages requires major efforts, there are fortunately very many valuable applications that have a limited and well-structured vocabulary [3,6,7,13,14]. This is in our view a key observation, useful to quickly develop Web-related facilities for voice.

Another key observation is that there is a need to be *independent from the cloud*, broadband, and similar heavyweight provider platforms that are taken for granted in the West, but plainly are an illusion in the Global South. The *Foroba Blon* app, for example,

shows not only that local language interfaces are crucial, but also that independence from expensive telecoms companies is important in achieving sustainability [4]. (This independence to reduce provider-induced costs was actually expressed by the radio station itself). Furthermore, this case provides evidence that many opportunities are now missed in proclaimed Corporate Social Responsibility, even ones that directly relate to core business. Once again, this points to the importance to care for the Web as a public and open good, and conduct public R&D with open public access to results that extend it, also for the Global South.

In sum, if the Web is to become *truly* inclusive, it is in need of *Web extensions* – also outside the Web proper – that cater for speech and voice services in the very many local languages that are now unsupported. This is a big challenge for Web research, and one that is currently underrecognized and underresearched. In an analogy to hair extensions (looking like having hair where you don't really have it), there is a need for Web extensions: having Web-like functionality, especially in the realm of speech and voice services, even where internet and Web are not available. The often expressed desire "*to make everyone's voice heard*" as a motivation to strive for better Web access is therefore to be taken in quite a literal, that is, voice-based sense.

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