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Advancement through Interactive Radio

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Abstract—**This paper describes the rationale, design and implementation of a system for increasing the status and involvement of women in developing communities. AIR (Advancement through Interactive Radio) adds interactivity to community radio, giving community radio listeners, especially women, a voice with which to respond to programming, and to participate in the creation of programming content. We first describe the cost of excluding women from Information and Communication Technologies (ICT) for development, and explore how community radio represents a potential antidote to this exclusion. We draw upon ethnographic data collected through feasibility studies and site visits in Southeast Kenya to support the introduction of a mechanism that enables women to "talk back" to the community radio station, in order to better facilitate participation. Using the principles of Participatory Action Research (PAR), we argue that women will be more likely to benefit from technology-mediated opportunities for development if they themselves produce information that contributes to their advancement, rather than simply consuming information created for their use. Finally, we describe the design and implementation of simple communications device that supports this model. This hand-held device enables women to record voice feedback and news for community radio at the touch of a button. This feedback is then routed asynchronously back to the radio station through a probabilistic, delay-tolerant network, where the feedback can inform subsequent broadcasts and facilitate additional discussion. We conclude with a technical summary of the AIR prototype, which will be deployed in Kenya in Fall 2007.**

Index Terms— **ICT, community radio, women, gender equity, development communications, delay-tolerant networks (DTN), store-and-forward, Africa, India, Participatory Action Research (PAR).**

I. Women and Development

Our interaction with Kamba women in Southeast Kenya has confirmed the observation that "the poorest people are women; however, the poorest of the poor is the African woman."[1]. Sub-Saharan Africa continues to be the lowest-ranked region in the United Nation Development Programme's 2005 Human Development Report [2]. The region is failing to achieve the milestones of Millennium Development Goal 3: *Promote gender equality and empower women* [3]. Perhaps more strikingly, sub-Saharan African women have actually experienced a decline in their living conditions and status over the past three decades. HIV/AIDS, famine, and poverty disproportionately affect women, since they not only suffer from these conditions, but are typically the designated caretakers and providers of others so afflicted [4,5]. These gendered aspects of poverty and unequal development of women continue even though there is increasing evidence that sustainable development initiatives can only succeed when women benefit to the same degree as men [6,7,8].

We contend that one of reasons women bear such a disproportionate share of the social burden associated with regional crises is their lack of access to the very information that could help them mitigate or manage these crises. Women's lack of access to information and education, as evident in the HDR, remains a huge barrier to their advancement, despite the billions of dollars that are spent on ICTs to promote access to information and close the "digital divide" [9,10]. ICT initiatives generally fail to take gender-specific barriers to ICT access and use into consideration: literacy, training, cost, time, safety, and gender segregation among other cultural factors [11,12,13]. By ignoring gender differences in ICT programs and policies, women are further excluded from the benefits of technical advances, and gender inequities are further perpetuated [14]. As Hafkin observed, "Left alone, societal forces will prevail, and women will get left behind." [15]. This marginalization is perpetuated by the conception that technology is a meritocracy where all stand to equally benefit and advance, or that developers and providers of

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ICTD are not responsible for looking specifically at gender but relegating this to non-governmental and community-based organizations – arguments that are often leveled at those of working at the intersections of gender, technology and development.

Meanwhile, issues of gender and technology are routinely positioned as side conversations in both the development and technology arenas, which has marginalized the subject even further, and led to positioning the "digital divide" as the disease, and not the symptom, of uneven development [16,17]. Placing women on the far side of the digital divide/digital inclusion spectrum ignores women's agency. In her report to the ITU, Bisnath contends that women will indeed take the "ICT leap" to the degree that their countries can support the leap, and the "political will exists for them to gain access to education, training and employment opportunities" [18].

Without this political will, it is likely that women will be further excluded from the benefits of technical advances, which risks exacerbating existing gender inequities pervasive in the Global South [19,20]. Lack of information, and access to the information that can help mitigate the social burdens of poverty, contributes to an on-going socioeconomic crisis for many women in these regions. While formal education systems may reach school-age girls, poor women do not typically have access to the formal and informal education available from Internet cafes, kiosks and community media centers [21]. This complex issue has been examined from several theoretical perspectives [22,23]. PAR suggests a more pragmatic approach: identify a communications medium in broad use (in this case, community radio), and seek to involve women directly in community participation and information exchange. The resulting project promises to advance women in the served communities, as well serving as a vehicle for interesting technical and social research.

II. Africa's Internet

Mary is over sixty years old, she thinks, although she looks a good deal older. Perhaps her wizened face and manner have contributed to her nickname Yoda. "Why Yoda?" we ask, noting this striking coincidence between the Ki-Kamba language and Star Wars. "Yoda like in Star Wars," we are told. "Have you seen Star Wars?" "No. Why?" Our guide from the local community radio station, Radio Mang'elete, laughs. Mary is the leader of one of the 34 women's work collectives (*mwethya)* in the area and is a respected community elder, due in part to her longevity, both as a member of the community, and as a long-serving collective leader. We have been told to bring our ideas about involving women in community radio to her attention – she will tell us if any have merit.

We spoke with Mary in a small wooden structure where she sells washing powder in tiny sachets. Under a faded OMO sign, she confirms what our background research has suggested. Star Wars and Unilever may have found their way to Nthongoni, Kenya, but "globalisation from below" -- made popular in the development community with the publication of *Space, Place and Gender* [24] – was not associated with the information and goods that were being delivered to Mary and other women in a variety of forms, including Radio Mang'elete. Yes, Mary said, of course all women listen to the community radio station. What other information is there? Everyone listens, all day. But when we asked her how she channeled feedback and questions to the station, she gave me a look similar to the one we received when asked about Star Wars. "We don't have phones. We don't have money for phones. There's no power for phones. How could I talk to the radio station?" Then she remembered that once, in fact, she did call Radio Mang'elete. She was in the somewhat larger town of Mtito Andei, 15 kilometers away, and her son called up the station on her birthday and let her announce her birthday to the greater community. When we ask Mary if there are topics she'd like to address with the station, the list is long. This was true of all subsequent interviews – men routinely contact the radio station, women typically do not.

This conclusion is further supported by the station log books. Less than 5% of any incoming calls or letters to Radio Mange'lete come from woman. While literacy rates and work demands may in part explain this discrepancy, these data expose the contrast between the promise and the reality of community radio. This contrast is not unique to community radio –inequitable gender representation is present in many development initiatives [25].

III. The Promise of Community Radio

In spite of these problems, and even though radio does not have the high-tech cachet of more sophisticated ICTs, it is enjoying renewed interest in development circles [26]. "Low-tech" ICTs like radio offer more appropriate and sustainable development solutions than advanced ICTs which often fail to live up to their promise of societal transformation [27,28,29]. The apparent failure of some higher-tech ICT solutions to take root calls for a critical

evaluation of the exuberant promotion of Western-style ICTs. A growing body of research has examined the challenge of implementing high-tech ICTs in the Global South, including discussions on the normative nature of Western ICT initiatives and the significant economic, social and political challenges that hinder ICT implementation and deployment [30,31,32,33,34]. These concerns have helped fuel renewed interest in radio by those who had earlier devalued radio as an "old" ICT, rather than one that is uniquely positioned as an appropriate and accessible foundation for addressing ICT for Development goals. The development communication community has recognized the value of community radio since the early days of agricultural radio in Africa (Zambia) and in local initiatives such as the Bolivian Tin Miner's radio [35,36].

Community radio's visibility is aided by prominent advocates of low-tech, such as Kenney [37], as well as by favorable changes in broadcasting and IT policy. While only one person in 160 in Sub-Saharan Africa has access to the internet, one in four is reported to own radios [38]. Radio networks reach over 60% of the population, and this coverage grows yearly [39,40]. There are several hundred community radio stations across sub-Saharan Africa, and India has recently legalized community radio broadcasting. In India, community radio NGOs have yet to secure their broadcast licenses, in part due to an array of administrative barriers that serve to restrict the emergence of alternative development strategies in a country where media control has long been national policy. Across the Indian Ocean, some African countries are liberalizing media ownership. As a result, community radio, as an alternative to mainstream and government-sponsored media, is flourishing in countries where conditions are favorable [41,42,43]. According to the World Association of Community Radio Broadcasters (AMARC), the number of community radio stations in sub-Saharan Africa has grown from 10 to more than 800 in the last 20 years [44]. Jean-Pierre Ilboudo, a development communications expert with the Food and Agriculture Organization of the United Nations, states that "community radio is Africa's Internet. It reaches our most important audience -- the illiterate and hungry." [45]. He also posits that the popularity of community radio is rooted in its similarities to the region's tradition of oral communication [46].

While community radio is typically focused on the needs of the community it serves, it often mirrors the gender gaps that exist in a given community. Radio may offer the greatest reach and accessibility to women, but it is inherently unidirectional, which limits the direct involvement of individual women and challenges the axiom that community radio is the "voice of the community." Given both their workload and lower status in the community, women also have fewer opportunities to be involved with station management and content production [47]. Despite these limitations, community radio remains both accessible and popular with women in Africa. Women's radio listenership is high; the ubiquity of home-located and portable radios serves to remove some of the most substantial barriers to access.

In a 2000 study of three thousand poor, rural women in four sub-Saharan countries, 91.1% of respondents indicated that they listened to the radio. 67.8% of these women indicated that they, not their husbands, owned radio sets [48]. This percentage is far higher than the frequently cited statistic that one in four people in developing regions own a radio. Over half of the women who answered that they owned radio sets also said that they independently chose the radio programming to which they wished to listen, as opposed to 16.7% who said that their husbands set the dial [49]. A 2005 study on women's radio ownership and use conducted by USAID in Mali found that 90% of the 1156 women surveyed listened to the radio. The remaining ten percent who reported that they did not listen to the radio belonged to the most economically-challenged class, and did not have the resources or ability, given their daily tasks, to listen [50].

Community radio programming is also cited as an effective strategy to counter detrimental attitudes and behaviors towards women. The online magazine "Business in Africa" credits community radio with increasing cultural and religious diversity in Kenya, and for kick-starting economic empowerment programs for women in Tanzania and Uganda [51]. One woman in Mali offers testimony to the effect of community radio on literacy: "*The station has helped us understand the importance of literacy for our commercial activities. It has encouraged the women to devote more time to this."* [52]. Another example comes from a community radio effort in Zambia, where a male listener reports: "*The other programme I like listening to is on orphans, vulnerable children and widows. Before we had this radio station, we had a lot of property grabbing taking place…Through this programme, people have been educated to respect widows and where there is a will, to honour it.*" [53]. Community Radio station KKCR in Kibaale, Uganda conducts specific domestic violence prevention and conflict resolution programs, inviting men and women on the air to discuss their stories. Men who do not abuse women are lauded on the air, and enjoy recognition in the community that is enviable and thus emulated.

Several stations across Africa have sought to integrate women's interests and community "participatory" in community radio programming [54]. These efforts often fall under the purview of larger umbrella organizations

such as the African Women's Media Center and the Federation of African Media Women [55]. The Federation of Africa Media Women, for example, has established women's radio listening clubs as part of their "Development Through Radio" (DTR) program in 12 countries; there are 52 clubs in Zimbabwe alone [56,57]. DTR groups meet specifically to listen to the radio, discuss issues raised by programs, and use tape recorders to deliver feedback on programming to the station. However, critical reviews by program administrators speak of a "serious gap" in understanding of the impact of DTR, as well as the decreasing use of participation due to tape recorder complexity and the need to manually deliver the tapes [58]. Case studies of DTR recommend the creating of a two-way communication model in broadcasting for development in order to address a variety of community misconceptions, provide an opportunity for community members to express themselves, and to facilitate "the tapping of indigenous knowledge, which development specialists are beginning to acknowledge as one of the missing dimensions in development" [59]. In his book "Community Radio and Its Influence in the Society," Joseph Okechukwu Offor echoes Matewa, asserting that in order to truly promote and sustain social and cultural change, health education and religious tolerance, community radio needs to be not only "a means of transmitting to people", but also a means of "receiving from them." He goes on to explain that "It has to be a radio that allows rural listeners not only to hear but also to be heard" [60].

IV. Broadcasting Women

In developing regions, making the private public through radio may represent women's only opportunity to have a public "voice," even if their views are represented by the few who operate as broadcasters. Given radio's inherent unidirectionality, it speaks *for* the community, not *through* the community. However, this indirect representation creates an effective "alternative public space" where women can bring domestic issues (e.g., water, housing, and healthcare) forward, in order to politicize those issues, and to create action plans to address them [61]. The trend is positive, as "there are now new openings to women to express themselves. Women today are breaking the bonds of silence… refusing to retreat before the many obstacles (lack of legal status, contacts, and experience, no access to credit of extension services, illiteracy, etc.)" [62].

While Radio Mang'elete in Southeast Kenya is the location of our pilot deployment, we conducted surveys and focus group studies among women from several communities in Kenya and Uganda. We found nearly universal desire among the women interviewed to be able to contact their community radio station. We were somewhat surprised by the interest women had in hearing their own voice and name on the air. When we asked women about the need or desire to disguise their voices when discussing controversial or sensitive topics on air, most women eschewed this idea, to the point of insisting that if their real voices were not used, they would not use the device. Thus, while the AIR device is technically capable of disguising voice, we have yet to meet a woman who wishes to use this capability. The women with whom we met were never far from a radio – most had a portable radio in their shops, homes and fields. They also described how they negotiated possession with their husbands. Radio sharing is common, and radios are widely viewed as a community resource [63]. While some radios were rigged to car batteries and generators, and some were hand-crack models, most were battery operated. However, the women told us that buying batteries was not an option for them; their husbands managed the finances and bought the batteries. We will therefore provide a solar-powered recharge option for AIR.

Cell phones have been suggested as an alternative to the custom AIR device. We rejected this approach, at least in the near term, for several reasons. Many rural communities in the Global South simply do not have cellular service. Further, several Kenyan women in an area with at least partial cellular service were adamant that anything resembling a cell phone would likely be taken by their husband and sold. In contrast to the successes of cell-phone-based initiatives such as the GrameenPhone [64], this observation highlights the non-universal nature of developing communities, a reason why local PAR efforts rarely scale with success [65].

Our first trip to Kenya provided the opportunity to collect input from prospective users and radio stations regarding potential AIR functionality and features, as well as to collect topographic data. On our second trip to Kenya, we conducted what in PAR parlance is called a "Search Conference", essentially a meeting of all project stakeholders, or more realistically in development work, as many as can be involved and accommodated [66,67]. PAR is rooted in Freire's model of emancipation through dialog [68], and thus aims to "empower" participants through knowledge creation and subsequent action [69,70,71]. Central to Friere's model is dialog – people must speak about their experiences in order to create an analytic condition from which to take action; it is in these dialogs that individuals uncover the truth about injustice and can develop strategies for positive change [72,73].

At the Search Conference, representatives from the 34 mwethya that comprise group activity in the three major communities around Radio Mang'elete (Nthongoni, Ivongoni and Masongaleni), curious men, station staff and local government leaders met with us to provide feedback on the device prototype (which was demonstrated), discuss operational specifics such as device stewardship and usage logistics, and to mediate the women's expectations of Radio Mang'elete regarding the broadcast of their content with how the station envisioned the use of this content. Subsequent meetings have been held with individual mwethya, which range from twenty to one hundred members, to gather baseline data about the perceived effectiveness of Radio Mang'elete as an information source, and to draft a framework to help facilitate equitable use of AIR within the mwethya. In addition, Radio Mang'elete has started a Women's Hour, hosted by one of the station's two women broadcasters (there are fifteen male broadcasters), which will solicit topics from mwethya via AIR. The station's second new show, News from the Field, will air news reports that mwethya members send regarding notable events in their immediate communities. News sourcing is currently a major gap, as the station only has two investigative "reporters", and only occasional use of an NGO-sponsored vehicle. Veracity is also an issue. Radio Mang'elete's station manager states that "Men will say anything to get on the air. We can trust news from women."

Once the prototype AIR device was described, Search Conference participants suggested a few additional capabilities that they desired. They also validated our decision to support only asynchronous listener feedback. This was a design trade-off that we had struggled with, stemming from our need to enable women to use the device in a variety of locations (some far from the station or other devices) such as market day, trips to the nearest "city," or a desire for distance in order to privately prepare a recording. The work of First Mile Solutions and DakNet was encouraging in this regard, as it demonstrated the successful use of asynchronous data exchange [74]. Radio Mang'elete also supported this model, since the station is only sporadically staffed, and all voice content needs to undergo sorting, analysis and pre-processing before it can be purposed for on-air use. Mwethya members also agreed to the "main collection device" design alternative (described in the next section) for obtaining listener feedback from outlying areas. Finally, they raised concerns about the reliability of the transmission, requesting a way to be notified that the station had received their voice. This capability had already been designed into the AIR device.

While PAR handbooks illustrate the community involvement in PAR projects as an informing factor in the iterative process of diagnosis, prescription, implementation and evaluation [75], we realize that there are two cyclical processes involved in introducing AIR into the community. As communities, both the mwethya and the Radio Mang'elete station personnel will undergo their own process of evaluation and implementation, based upon their unique experiences and expectations of AIR and of each other. We have therefore extended Stoecker's basic four-part taxonomy for PAR phases [76] into what we call an "Action Cycle". The Action Cycle represents a framework for tracking the iterative phases of the project from both the researcher perspective (the Researcher Cycle), and the community perspective (the Community Cycle). These processes are depicted in Figure 1.

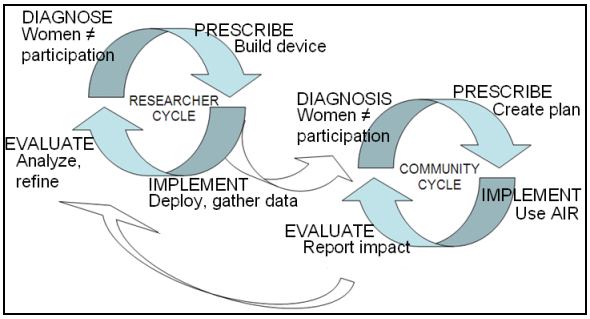

Fig. 1: Iterative stakeholder "Action Cycle" for AIR project

V. AIR Design and Implementation

The design requirements for the AIR device were developed based upon information collected from community radio listeners, station managers, station operating personnel, and community radio NGO leadership. These requirements also reflect standard recommendations for implementation of ICT4D projects, such as Heeks' theories of effective "gap closure" [77]. In this section, we describe the design and implementation of the AIR device. We describe the AIR device hardware, the network architecture used to link AIR devices, the power management

system used to keep the devices operating in the field, and the base station hardware and software with which AIR devices communicate.

A. AIR Device

The basic hardware architecture of the AIR device is shown in Figure 2. The device employs a common low-power ARM processor. The primary system interconnect is an SPI bus that is supported by both the processor and the selected interface devices. We made a convenience-over-cost design decision to use commodity 802.11 and Flash RAM USB devices for networking and storage, respectively. In addition to reducing design time, this decision allows us to vary the amount of voice storage, as well as to experiment with several different 802.11 devices[*]. User speech is amplified and passed through a low-frequency bandpass filter before A/D conversion. This filter minimizes memory usage for voice storage, without significant loss of fidelity. The high frequency cut-off of the bandpass filter is optimized for female voice ranges. Externally visible input and output devices include a microphone, a "push-to-talk" button, and three status LEDs (green, yellow, and red). These LEDs provide a variety of feedback regarding device status to a sophisticated user, but in general terms, green means everything is "OK", yellow means that the device needs to charged or emptied soon (both of these activities take place at the provided community charging stations, so a yellow LED is easily interpreted as "take the device to a charging station as soon as convenient), and the red LED means that the device must be taken to a charging station as soon as possible. Since user voice input is stored in non-volatile Flash RAM, there is no loss of data even if the device batteries are completely discharged. The AIR device is enclosed in a rugged plastic housing measuring approximately 7.5x15x2.5 cm. Fully configured, the device weighs less than 100 grams. Over half of this weight is represented by the four rechargeable AA batteries that power the device.

The design of the AIR device is optimized to minimize power consumption. Under normal usage, we expect devices to operate for about a week without need for recharge. The device incorporates an efficient switch-mode voltage regulation circuit that provides the various required operating voltages. Finally, the AIR device may be connected to an external board that facilitates debugging and software development.

The AIR device software is stand-alone (i.e., there is no resident operating system). A dedicated event-driven program initializes the device, and then enters a continuous loop that monitors device inputs and responds appropriately. When a woman presses the push-to-talk button and speaks into the device, her voice is filtered (in hardware) and compressed for storage using the Speex VOIP codec software [76]. The resulting content is then stored in the Flash RAM. Transmission of the stored voice is accomplished as follows: Each voice message is tagged with a unique field of separately-stored metadata that indicates the originating device and message recording time. This metadata is used by all devices in the system to track message status. When a device comes within range of another device, the devices exchange metadata, allowing each device to pull or to push particular messages. Assuming the device has not already processed the message, whether a particular message is transmitted depends upon a probabilistic adaptive algorithm that makes this decision based upon (1) the number of other devices to which the message has been successfully transmitted (the more devices that receive the message, the higher the likelihood that the message will reach the radio station); (2) a measure of device mobility (a historical record of the number and diversity of devices that have been recently in-range); (3) available power (devices will reduce transmission rates when low on power); (4) the number of devices in range (messages need not be transmitted to every device in range), and (5) the state of these devices in range (messages should only be sent to devices that have adequate capacity and power). The parameters that guide these choices are adjusted from their initial settings based upon the device's success in ultimately getting all messages to the radio station. The idea is to use the minimum number of redundant transmissions to other devices (and therefore power) to accomplish this objective. If all messages get through, parameters are relaxed; if the objective is not met, transmission parameters are made more aggressive. The algorithm uses hysteresis to prevent oscillation.

[*] The decision to incorporate off-the-shelf USB "fobs" proved to be a mixed blessing, since we found very few commercial USB wireless devices that were fully compliant with the USB 2.0 specification at http://www.usb.org/developers/docs, particularly as it pertains to entering the suspended state.

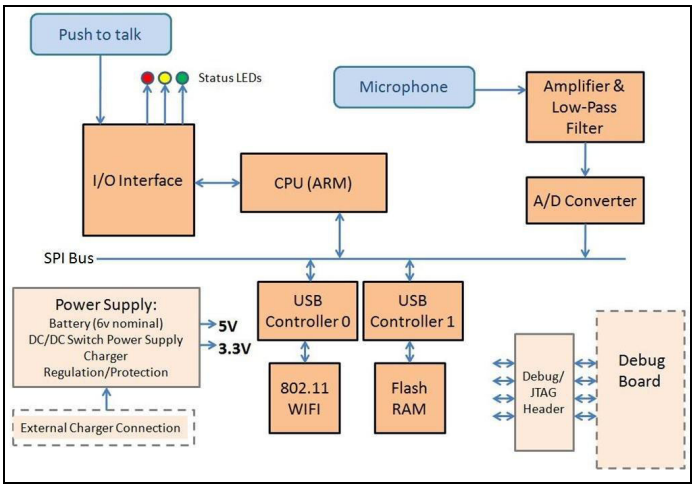

Fig. 2: AIR Device Hardware Architecture

B. Network Architecture

Message delivery is not guaranteed in AIR, and the network used to deliver messages is subject to frequent disconnection. Like ZebraNet [78], AIR therefore uses a Delay Tolerant Network (DTN) architecture. DTNs are designed to address the issues associated with intermittent connectivity and unreliable power, and where data rates can vary widely. While DTNs were originally designed to support interplanetary and military communications, disaster response, and underwater communication [79], the ICTD community faces similar connectivity challenges [80]. DTNs typically employ a Store-and-Forward (SAF) protocol such as that used in many voice mail and messaging applications. In Delay Tolerant Networks, SAF protocols are typically implemented over a protocol layer called the "bundle layer." The bundle layer consists of three components – a bundle header that contains addressing information, control information that encodes how to treat the data, and the actual user voice data. A significant advantage of this approach is that it supports heterogeneous transport and network layers, including TCP/IP [81]. Thus, as other ICTs are introduced into the region, there will be opportunities to extend the existing AIR infrastructure to take advantage of additional development services such as e-Government and education initiatives.

While SAF protocols have been used since the mid-1990's, to the best of our knowledge, SAF has not previously been used in a radio application such as AIR. SAF protocols offer capabilities that support the primary technical and user requirement of AIR – reliable delivery of voice packets to the community radio station, and reliable delivery confirmation.

C. AIR Charging Station

The charging station is powered by a nominal 12 volt supply. This power can be provided by a 12 volt automobile battery (that is charged via a medium-sized solar panel and simple charging circuit), or, where utility power is available, by a provided 220V to 12V power supply. We have observed that used automobile batteries are ubiquitous in southeastern Kenya, and in fact the power provided by vendors of power from this source makes up a substantial grass roots power industry. Prospective AIR users were enthusiastic about having an additional automobile battery power source, apparently in anticipation of using the battery for other purposes (such as providing charging power to the (mostly male) cell phone owners in the community. Since the recharging stations have the capability to provide more power than AIR device charging is likely to require, the mwethya in each community can use the recharging stations to generate extra income for their groups by offering an additional power supply source for the larger community. As part of group readiness for AIR deployment, each mwethya (and groups of mwethya in the three general communities) committed at the Search Conference to develop a plan for public use and revenue-sharing of this new community power source.

D. Base Station

Although the radio station could simply use a dedicated AIR device for collecting voice feedback, this would require that users go out of their way to get close enough to the radio station for data transmission to occur. Instead, we employ a Fidelity Comtech Phocus Array™ steerable phased array 802.11 antenna mounted on the

radio station transmission tower. The antenna is programmed to sweep a semi-narrow beam across the area occupied by the nearby community, and then to dynamically reshape the antenna pattern to point and narrow the beam when a device is detected. This increases the signal range and improves network reliability. Since the antenna is capable of this dynamic beam shaping on a packet-by-packet basis, multiple devices in different locations can all enjoy the increased range and reliability. Other than the specialized antenna control, the remainder of the base station 802.11 system is essentially no different in function from the system used in the AIR device.

Although the phased array antenna will increase data transmission range considerably (to include all of the community of Nthongoni, where Radio Mang'elete is located), the outlying communities of Ivongoni and Masongaleni (where eight of the thirty-four mwethya are situated) cannot be reached directly. In these cases, one AIR device in that community will serve as the "main" collection device. These designated outlying community collection devices have expanded voice storage capacity, and are programmed to promiscuously collect voice input from all other devices in range, but otherwise function as standard AIR devices. The collection devices are taken weekly into Nthongoni on market day by women from these outlying towns who already routinely make this journey to sell their goods at market. The stored voices from the designated collection devices will then be transmitted to Radio Mang'elete as described above.

Once the radio station has received and stored a particular voice message, an acknowledgement packet is sent to the transmitting AIR device. The device can then recover the buffer memory used to store that message, but the message metadata is retained, so that other devices with which that device comes into contact will receive the acknowledgement packet, indicating that they too can reclaim their buffer memory. Once the originating device has received the acknowledgement, all AIR devices can delete all references to that message. This is accomplished by marking the message metadata appropriately and forwarding the revised metadata the next time metadata is exchanged. This process will eventually clear all buffers and metadata associated with that particular voice message.

Voice messages are stored on the station PC after conversion to a format that can be used by the station audio editing software (in the case of Radio Mang'elete, Adobe® Audition® is used for this purpose). Once stored for editing, station personnel review and process the voice input for potential broadcast in the same manner as all other programming content.

VI. Current Status And Next Steps

A. Air Deployment

We are preparing to deploy an AIR device to each of the thirty-four mwethya served by Radio Mang'elete. Basic device operation (push-to-talk functionality, and the meaning of the LEDs) was discussed with users during the Search Conference using a device prototype. During deployment, Radio Mang'elete will conduct training workshops in the various communities served.

We are also deploying a pilot in Bangalore, India. This effort is undertaken in partnership with VOICES, a community radio NGO that is also part of the AMARC federation, and that has been active in advocating the legalization of community radio in India. While the legalizing policy is now in place, NGOs must operate under a broad set of restrictions, including the requirement to broadcast from an educational institution with an existing and approved transmitter [82,83]. As part of the deployment in India, we seek to understand whether AIR will help build an audience for nascent community radio efforts, given the competition that community radio faces from congested radio airwaves and high television viewership, even in slum communities. For example, 50% of homes in India have TV sets compared to 2.3% in sub-Saharan Africa [84]. In the India pilot, scheduled to begin in early 2008, AIR devices will be given to women's self-help organization in peri-urban slums where VOICES is targeting its development efforts.

B. Future Work

We have begun to compile a desired features list from users. A feature receiving significant interest from both mwethya representatives and radio station personnel is the integration of an FM radio receiver with the AIR device. The architecture of the AIR device can easily handle this addition, but the negative impact upon power consumption could be significant. We have also received requests for the ability to handle multiple destinations, so that voice messages could be routed to additional destinations (police, NGO offices and each other); the ability to

support erase/re-record/listening functionalities like tape recorders; and a back-haul solution for longer-distance transmission.

We have conducted exploratory conversations with health and microfinance NGOs who are investigating the use of AIR in scenarios where it is as necessary to receive information from the community as it is to deliver information to the community, especially in areas where the infrastructure or culture challenges more sophisticated technologies. We are also monitoring the growing use and convergence of community radio and Internet Radio, including some forays into software-defined radio [85]. While expanding into different development areas is not a primary goal of AIR, we are interested in making the source code and hardware design available to other academic or development institutions, provided it is used solely for ICTD purposes.

VII. Conclusion

The AIR project seeks to advance women in developing regions by offering them a mechanism to amplify and publicize their unique concerns, knowledge, and needs. Critical of community radio's claim to be the "voice of the voiceless," we contend that direct interaction between women and community radio will positively influence community radio programming, ultimately benefiting both women and the larger community. During deployment, we will critically examine the cognitive and operational changes that women may perceive as attributable to AIR. Ongoing interviews and post-project surveys -- grounded in PAR, Participatory Evaluation and Gender and Development theory will inform our evaluation on the impact of the AIR project.

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