Technology for Emerging Markets at MSR India

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ABSTRACT
The Technology for Emerging Markets (TEM) group at Microsoft Research India seeks to address the needs and aspirations of people in the world's developing communities. Our research targets people who are just beginning to use computing technologies and services as well as those for whom access to computing still remains largely out of reach. Most of our work falls under the rubric of the relatively young field of *Information and Communication Technology for Development* (ICTD or ICT4D). Reflecting the interdisciplinary nature of ICTD, TEM is a multidisciplinary group engaged in a range of technical and social-science research. We work in the areas of cultural anthropology, sociology, political science, economics, and psychology, all of which help us understand the social context of technology and how it relates to communities and individual users. We combine this understanding with technical research in hardware and software to devise solutions for underserved communities in rural and urban environments around the world.

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ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Experimentation, Human Factors

INTRODUCTION
When Microsoft Research established a lab in Bangalore, India, in 2005, one of the first questions that the founders asked was, "What should we work on?" They considered many of the core topics in computer science, but they also wanted to focus on areas of research that would take advantage of the location of the new lab. One of these was the nascent area of ICTD, exploring how computing might be used to help solve some of the many problems in global development.

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Figure 1. Bangalore is an excellent place to explore the intersection of technology and global development.

India is a particularly interesting place to research ICTD. Home to about one-sixth of the global population, India is a place of dramatic contrasts. While it plays host to some of the most elite technical universities in the world, India's literacy rate is barely 66% (the largest illiterate population of any country); and while India is becoming a world leader in high-end healthcare and pharmaceuticals, the infant mortality rate remains extremely high at 52 deaths per 1000 live births, more than seven times that of the USA [30]. India is making great strides economically and technically, but clearly many challenges remain. All of this makes India an ideal place to explore how computing and information technology can help to improve socio-economic development.

In the past five years our research staff has grown and personnel have come and gone, but the group has remained multidisciplinary. Currently, TEM includes experts in cultural anthropology, public policy, economic development, communication, design, HCI and computer science. While our research tends to focus on India, we believe it is important to explore the needs of people across the world. TEM has completed projects in five countries and participated in studies in more than thirteen. In addition, one of our researchers is currently based in South Africa, giving us some insight into a dynamic developing milieu that is very different from India.

Complementing the work done by the full-time research staff, the MSR intern program has been enormously

successful for TEM. We have played host to dozens of undergraduate and graduate research interns from around the world and from a range of academic disciplines. Our multidisciplinary team and the location in India combine to make TEM an excellent (and unique) place for students interested in ICTD to come and do research. They are also very productive: since 2008, research interns have been first authors on approximately 20 peer-reviewed papers, secondary authors on many more, and named as inventors on several patents.

There are three core goals of TEM research:

- Understand existing and potential technology users in developing communities
- Design and evaluate technology and systems that contribute to socio-economic development of poor and developing communities worldwide
- Collaborate with development-focused organizations, governments, and industry (particularly Microsoft product groups) for sustained, scaled impact

In pursuit of these goals, TEM has engaged in a variety of research projects, ranging from agricultural extension to studies of micro-entrepreneurs in slum communities. Methodologies include ethnographies, surveys, action research, field deployments and many of the standard tools of HCI research (though these methods often need to be adapted to a developing-world context [11]). One key characteristic of most of our work is partnership with organizations that are focused on development. These collaborations help guide the potential utility of our work, giving us a path from research prototype to sustained impact.

Perhaps the single most critical thing for our research is the ability to work in the field, observing firsthand the reality of technology and social structures of the communities we wish to work with. The proximity to the field to Bangalore is a huge benefit of our location. The ICTD literature is littered with failed projects that crashed up against fundamental problems that could have been predicted if researchers had better understood the context of the people and venue of the area they were working in (and we have learned this firsthand through brutal experience) [6]. This is another area where partnerships with competent development organizations are tremendously helpful. Partners often point out important political or practical considerations that are not obvious to outsiders, saving us a great deal of work and potential dead ends.

In this paper, I will briefly describe some of our projects that may be of interest to the CSCW community. While this is certainly not an exhaustive list, I hope that it will be sufficient to give a sense of the kinds of research TEM engages in.

PROJECT OVERVIEWS

TEM projects come in a wide variety of flavors and scales. Some projects fit neatly into application domains such as education [4, 7, 15, 20], healthcare [17, 23], agriculture [5] or financial services for the poor [3, 12, 13]. Other research focuses on exploring a general class of technology, such as the use of internet kiosks [23] or how people in the developing world use mobile phones [2]. And still other work explores how to design interfaces for non-literate populations [12] or asks very basic questions about how users in different contexts interact with technologies [27].

One thing that characterizes almost all our work is a general wariness of purely technical solutions to problems in ICTD. Information technology, like *all* technology, magnifies human capabilities but by itself has little relevance. Therefore, in our research we try to foreground considerations of human capital and existing social structures and their interplay with technology. Our focus on fieldwork keeps our work grounded in the reality of the communities we are studying. And the interdisciplinary nature of our group gives us the tools to keep technical, design and sociological considerations in mind for any project.

In the following pages, I will discuss a sampling of a few recent projects that may be relevant for a CSCW context and should give a "feel" for what we do.

Financial services for the poor

One major area of focus for the development community is providing banking and other financial services to poor communities. An estimated 3.5 billion people worldwide currently lack access to formal financial services [22]. We see a great deal of promise for ICTs in helping to create access to these services for poor, unbanked people in the global south. To that end, researchers in our group have initiated several different projects in this area.

Mobile banking is currently receiving a great deal of attention. There are more than a billion people who do not hold a bank account but who still own and use a mobile phone on a regular basis [22]. Services such as M-PESA in Kenya, G-Cash in the Philippines, and many others have demonstrated that the mobile phone can be an effective means for providing access to banking services for the poor. Indeed, G-Cash in the Philippines is transacting more than $100 million on a daily basis [10]. While this is very exciting and points to the huge potential of m-banking, there remains a great deal of research on how to achieve this effectively. Among other work in our group, Jonathan Donner, Indrani Medhi, and Olga Morawcynski (a research intern) led ethnographic investigations of m-banking and financial inclusion initiatives in India [3, 12, 13]; and Saurabh Panjwani has been exploring techniques for overcoming the unique security challenges associated with banking via SMS on inexpensive phones [19].

Aishwarya Ratan leads another area of research that focuses on self-help groups for microfinance (SHGs). More than 6 million SHGs bring formal savings and credit services to more than 86 million rural, poor households in India [29]. Women meet on a weekly or monthly basis in groups of 10

to 20 and pool their savings in small amounts to borrow cheaply both from the group's own accumulated capital and from a linked bank [9].

One serious problem that SHGs face is the lack of reliable financial data management. Currently, there are two main arrangements for managing financial data for SHGs. In the first system, all account records are maintained locally in handwritten record books, but this leads to very poor accuracy and completeness. In the second system, a "federation" of 150 to 200 SHGs works with an accountant in a nearby town to update their records on a weekly basis. This leads to more accurate records, but the weekly cycle of sending paper records to and from the accountant is often disrupted by inclement weather, delays in error reconciliation or other issues, causing problems with getting timely information to and from the SHGs.

Over a period of 15 months, we worked with a group of SHG federations in rural India to devise a solution that could be used effectively by low-literate, low-income clients with very little training [25]. We created an application on a low-cost prototype handheld digital slate that accepts handwritten, pen-based ink input on ordinary paper forms and provides immediate visual and audio electronic feedback (see Figure 2). We tested this system in two field trials with 201 SHG members in rural West Bengal and Orissa. We found that the pen-paper-slate solution performed as well as a purely electronic alternative, and it performed better than the traditional paper-only system in improving data accuracy, data completeness and process efficiency.

While a number of factors led to the success of the system, we believe that two features were particularly important. First, note that many SHG members are non-literate. Indeed, SHGs often hire a literate person from the village to keep their records for them. One feature of our system was an automated audio feedback on dues and balances that members received immediately. This feedback was important because it provided each member immediate information for what their current financial situation was at the end of the meeting instead of having to wait for the round-trip to the accountant in the city to verify it. Just as important, this audio feedback helped to instill some trust in the system; there was no guessing whether the record-keeper had correctly entered their information.

Figure 2. Device being tested in the field by an SHG member who serves as the group's Writer

The second critical feature was the production of the paper copy of the account information along with the digital. This physical copy of the records is important because it provides insurance that the information is always available, a very reassuring thing for people who have very little experience with or access to digital systems and live in harsh environments where device failures are not uncommon.

Education

Education is regarded as one of the key enablers of economic mobility. In India, there are enormous hurdles to the provision of universal education, and our group has worked on a number of different projects aimed at understanding how information technology can be used to improve education for children and adults.

Computer-aided learning—MultiPoint, Mischief & Cloze

We have spent many hours in the field observing how computers are used in educational environments in the developing world. One consistent finding in low-resource schools is that even when computers are available for student use, computer-aided learning technology (CAL) is often compromised because machines are shared by several children at once. In such circumstances, the high-performing children sit in front of the monitor and control the mouse, whereas the rest are relegated to the sides to observe. Here, the main beneficiaries of computer-aided learning are the children who are already doing well [18]. This observation inspired the creation of *Multimouse* (now marketed by Microsoft as *MultiPoint*), a system for single-display groupware (SDG) in which each child is given their own mouse to use with a single, shared computer system (see Figure 3). While other researchers have explored learning improvements in SDG settings at a small scale (2-3 users) in wealthier contexts [8], we wanted to understand how these systems could scale and be used effectively in low-resource environments.

Research headed by Udai Singh Pawar shows that learning using MultiPoint with five users is at par with single-user scenarios, indicating that the benefits of computing can be inexpensively multiplied using multi-input, shared-user designs. Of course, the use of multiple mice in an SDG requires very different interaction models than single-user-single-mouse or multiple-user-single-mouse scenarios. We explored two different interaction designs: one in which competition was encouraged between users and another in which collaborative interaction was required. We found that while girls learned at similar rates in both models, boys showed significantly less learning when using the competitive model [21].

Figure 3. Children attempting to share (or not!) a single mouse (left). The same children using MultiPoint (right).

Since these early studies, we and others have extended the research on MultiPoint. For example, *Mischief* (initially developed by Microsoft Research Asia) is an extensible layer that sits on top of PowerPoint, allowing for interactive slides that support MultiPoint. Studies using the Mischief framework range from an exploration of the scalability of MultiPoint in learning (e.g., how many children *can* interact at the same time?) [14] to using it for synchronous distance-education scenarios (e.g., a remote math instructor teaching a rural class full of children) [15].

One thing that is often overlooked in CAL systems is how teachers might want to incorporate CAL activities into their existing curricula and classrooms. Authoring games or other learning content for systems such as MultiPoint or Mischief requires sophisticated programming skills that most teachers lack, particularly teachers in low-income schools in the developing world. And even if they *did* have the skills to develop such content, teachers are so busy creating lesson plans and grading student work that they have no time for it. As a result, very little customized content is created, and teachers often see computer-supported learning as somewhat superfluous, outside their lesson plans or irrelevant to the individual needs of their students. This leads many teachers to be ambivalent or even hostile to such systems.

To address this, David Hutchful developed *Cloze*, a content-authoring system specifically designed to help teachers with low computer proficiency develop SDG content for their classes (using MultiPoint, clickers or other hardware) [7]. The goal of Cloze is to make it easy for teachers to create and adapt CAL exercises for their students that are directly related to the content and pedagogy of their classrooms.

We found that a few elements were critical for acceptance of Cloze. Many of the teachers we observed are poor typists and are easily intimidated by software complexity. Cloze uses task-oriented, wizard-like interfaces that require only basic mouse skills and keep complexity at a minimum. This enhances teachers' sense of control and confidence in their ability to use the system.

In addition, we observed that while teachers work hard scavenging for content to use in their lessons, this content is generally paper-based and digitizing this content for CAL takes too much time and effort. As a result, we found that it was important to provide access to image banks or digital textbooks, which cut down on the time needed to find and digitize materials. The challenge here is to give teachers information that they can use but not overwhelm them with irrelevant content. Thus, if possible, the content primitives should be tailored to the particular information domain of the users.

Collage

While CAL applications focus on how children use computers in education, computers also can be used by teachers to improve traditional classroom pedagogy. To explore this, Saurabh Panjwani led an in-depth investigation of teaching practices in several low- to medium-income schools in India. We wanted to understand teachers' classroom needs as well as the ways in which they employed technology (if at all) while teaching. Powerful presentation tools such as PowerPoint are used extensively in teaching around the world, but our research suggested that such tools do not meet the pedagogical needs of the teachers we observed. After watching many classrooms and talking to teachers, we came to believe that a simple tool that enabled the display of images and textbook materials while facilitating blackboard-like interactions would be very helpful. To test this, we developed *Collage*[1], a proto-type media viewer with a small number of features that enbables teachers to prepare lessons with little overhead and then present them in classrooms with maximum flexibility [20].

As noted above, teachers are extremely busy and are reluctant to adopt any practice that requires additional time for preparation of classroom materials. Therefore one of the top priorities for Collage was to reduce the effort involved

[1] Collage is available for free download at:
http://research.microsoft.com/en-us/um/india/projects/edulab/collage.html

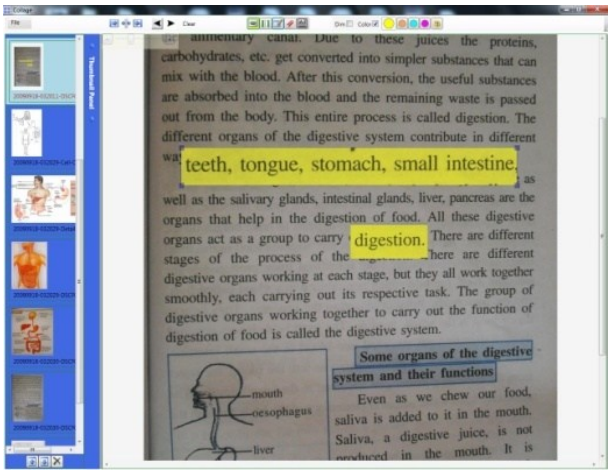

Figure 4. A screenshot of Collage.

in authoring presentations ahead of class. To build a presentation, teachers need to collect a series of images or videos into a single folder on the PC and then order them by prepending numeric labels to the file names. The preparation process is designed to involve very little typing (as we observed with Cloze, these teachers were poor typists) and uses only general PC skills (e.g., using the Web to find content and copying it into a directory).

In contrast to general-purpose presentation tools, Collage is basically a media viewer that can display digital images, videos and scanned copies of textbooks and other paper materials (see Figure 4). What differentiates it from traditional media viewers is that Collage enables users to interact with digital content—particularly content derived from paper—while it is being displayed. For example, teachers can use Collage to highlight and annotate different parts of a textbook, to overlay media elements on a textbook page and to arbitrarily switch between a textbook page and multimedia files as they present them to students.

As we observed in Cloze, teachers had a strong desire to use paper materials in class. However, in the case of Collage, they often found it worth the effort to digitize the paper materials in preparing classroom presentations. Teachers reported several advantages of this technique, and preliminary research in one of our pilot schools shows that intermingling textbook-based content with digital multimedia can improve students' retention of visual concepts. This is an interesting use of Collage, and it suggests several avenues of research in how to effectively help teachers in low-resource schools produce and interact with electronic versions of textbooks.

We piloted Collage in three schools in suburban India for use in real-world teaching. All teachers who used Collage praised it and reported that they preferred it to other presentation aids that they had used. An important measure of their approval is the fact that some teachers continued using Collage in their classrooms after the pilot observation period ended.

Understanding users in low-income contexts

Intermediated technology use in developing communities

A number of projects that TEM has undertaken have attempted to target very low income communities such as slum neighborhoods in urban India. A central challenge to this work is understanding how users of information technologies in these communities interact with the devices and services that are currently available to them. Ethnographic studies are an excellent tool for exploring patterns of use, limitations and work-arounds of information technology in such resource-constrained environments [28].

During a research internship, Nithya Sambasivan led an ethnographic study exploring the way in which people who may not be able to use technology (because of non-literacy, lack of technology-operation skills or financial constraints) benefit from technologies through other users who are digitally skilled [27]. These *intermediated interaction*s expand the reach of technologies to people who would otherwise be excluded. In these communities, informal help goes well beyond spot assistance and is a fundamental enabler of technology use and access for many people.

One thing that makes urban slum communities unique is the density of people living there. In the communities we have worked with, homes are typically no more than 12 square meters in size and are shared by multiple generations of a family. Homes are built adjacent to each other with small alleyways separating facing rows. In such an environment, one is almost never alone and there is a very high degree of interdependence among people in the community.

This density shapes how technologies are used in these communities. In intermediated interactions, we break apart the traditional notion of *user* into at least two people. First is the *beneficiary user* who instigates the interaction and derives direct value from it. Second are *intermediary users* who directly interact with the device or service to achieve some outcome for the beneficiary user. In a slum environment these interactions usually apply to technologies such as mobile phones, DVD players and occasionally computers. In this study, we identified three distinct forms of intermediated interactions:

1) *Surrogate usage*. In surrogate usage, the beneficiary user depends on intermediary users for technology access. The intermediary user in turn relies on technology-operation skills and physical or financial access to technologies unavailable to the beneficiary. Beneficiary users understand the function and purpose of technologies, and identify suitable intermediary users for specific tasks. For example, in our study, people with access to the internet at work would look up information and bring relevant printouts to friends, relatives, etc. (the beneficiary users).
2) *Proximate enabling*. In proximate enabling, the intermediary assists the beneficiary in overcoming complexity or other difficulties associated with using

technology. In this case, the beneficiary user might have direct access to the technology but cannot use it without assistance. For example, a daughter might help her mother access the contact list in her phone to dial a relative.

3) *Proximate translation*. Sometimes beneficiary users have access to and operational knowledge of a technology, but their usage is limited by a lack of textual literacy or knowledge of the language of the interface. Often, such users are able to use rote memorization of input patterns to achieve tasks, but any unexpected output or change in the interface will create a road block. When this happens, an intermediary user can translate unfamiliar output into a more familiar verbal form and assist the beneficiary user accordingly.

Such intermediated interactions change the way we frame a "user interface." The intermediated UI is a combination of the intermediating channel and the device user interface (see Figure 5). In order to successfully interact with a technology, the beneficiary user is dependent on the intermediary user to mediate the input or the feedback. For the beneficiary user, the user interface explicitly comprises the technology and another person.

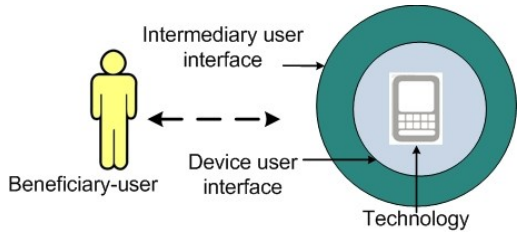

Figure 5. The intermediated user interface

This reframing of the user interface has important implications for how we design for low-income communities. We must revise our thinking on engagement with the user and the availability of the technology (the notion of anytime, anywhere access is obviously altered). This also raises issues for the accuracy of information input and output (information must pass through the filter of the intermediary) and important privacy concerns.

Although technology users everywhere use intermediaries from time to time (e.g., programming DVRs, Bluetooth phone pairing, etc.), intermediated interaction is more pronounced and more deeply embedded in low-income communities. Even if access to and familiarity with technologies is limited to a few individuals, intermediated interactions increase the number of people who can benefit from them. This type of interaction presents a rich area for HCI research, ranging from understanding how usage proceeds, to the design of UIs that cater simultaneously to two users who are not peers with respect to the technology. In turn, such research could help lower barriers to technology-based services for many people in the developing world.

Kelsa+

Most enterprises in developing countries employ support staff for a variety of tasks such as housekeeping, security, maintenance and transport. Many of these workers in India come from disadvantaged backgrounds, have limited education and earn $50-200 per month. There are very few on-the-job opportunities to learn new skills, and workers often remain caught in a vicious cycle of low-income work. MSR India employs a number of support staff and even though they are surrounded by computers every day, these workers have little or no opportunity to learn how to use them; in general, the machines are "off limits."

The idea for Kelsa+ (*kelsa* means "work" in Kannada, the local language in Bangalore) was to provide an internet-connected PC for the staff's free, unrestricted use when off duty. The goal was to study whether and how this availability would translate into usage, digital literacy and skill development among these low-income workers. Aishwarya Ratan is leading a pilot of this initiative at our facility in Bangalore, through which the ~35 workers employed as support staff have access to a dedicated, free-to-use, Internet-connected PC at the workplace [26].

In many ways, this project was inspired by the "Hole-in-the-Wall" experiments run by the National Institute for Information Technology (NIIT) in the late '90s with children from disadvantaged communities in New Delhi, India [16]. Effectively, researchers bored a hole in the wall that separated NIIT from the neighboring slum settlement and set up an Internet-connected PC facing the settlement, with a touchpad built into the wall for navigation. They found that children (mostly 6 to 14 years old) from the slum communities in the vicinity learned to use the PC on their own, resulting in significant learning benefits without any formal instruction. Similar interventions for children have been conducted at various rural and urban sites, and this pattern has been seen repeatedly [1]. Kelsa+ explores unrestricted PC access for adults instead of children and within an institutional and social context (e.g., the workplace).

Over the past two years, we have been tracking how workers use the PC. We have employed a number of qualitative and quantitative methods for data collection and analysis, including PC logging tools, a screenshot logger, webcams, questionnaires and several proficiency tests. Unsurprisingly, the facility is very popular and is heavily used by most workers. More interestingly, we have found that the usage of the PC in such a shared environment, with peer support and institutionalized maintenance, leads to gains in individual workers' basic digital literacy and related skills such as second-language (English) proficiency. In addition, we have seen preliminary gains in workers' self-esteem and career opportunities [26].

One very interesting facet of this project is the way in which workers learn to use the PC. A common pattern was for workers to observe their peers for weeks before

Figure 6. A group of workers using and observing the use of the Kelsa+ PC

attempting to touch the PC themselves (see Figure 6). As one worker commented, "For the first one and half months, I just watched how other people used the computer." We asked why he did this without trying to use the PC himself, and he responded, "What if something happened when I used it?"

Group usage of the Kelsa+ PC was very common, and peer learning was often critical for specific tasks or applications. For example, as described in [26], "…many workers had gone through the email account creation process with a peer who was an existing email user. During the registration process, in the space where a second email address was required (usually of the person creating the account), the experienced email user friend would enter his email address, since for most workers, this was their first email account. For other workers, group usage involved a symbiotic learning relationship: 'I use it with a friend generally, so that we can learn from one another. What he doesn't know I tell him, and vice versa.'"

Another interesting pattern of learning evolved from the group usage over time. We noticed that one of the important ways that workers learned about new applications or Websites to visit was by exploring the browser or application history. Since the machine was fully shared, this history was a valuable way to indirectly learn from other users. Workers would often browse the Web history to see what their peers were looking at; soon after someone visited a new site or started playing a new game, everyone would know about it.

While this is a fairly small-scale pilot, we believe there is a great deal of potential for extending this idea to a larger-scale implementation. Indeed, we have begun work with other companies in Bangalore to implement a similar system for their own workers so that we can understand how Kelsa+ may be implemented for a larger workforce in a different work context.

CONCLUSION

These are only a few projects, but hopefully they give a sense of the kinds of work that we do in the Technology for Emerging Markets group at MSR India. We believe that computing and information technology can be a powerful tool in improving the livelihoods of billions of people in the world who are struggling just to get by. But clearly a great deal of research remains to be done to understand how to achieve this.

The research community in computer science, HCI and related fields tends to focus on the global north, where IT is omnipresent and permeates most aspects of life. However, the use of IT is by no means limited to the wealthy quarters of the world. We believe there is enormous scope for research into the ways in which computing and IT are appropriated and used by people in broad swaths of society that are often overlooked. The context and lifestyle of a person in a rural village or an urban slum is not likely to be very familiar to someone in Silicon Valley. Nevertheless, they share many of the same needs and aspirations: connecting with family and friends, means of improving their livelihoods, a desire to provide for their families and children, entertainment, etc. The TEM group seeks to understand how people in disadvantaged communities use and can benefit from ICTs, and thereby to uncover or invent new means for helping them reach their goals.

Through careful study and the invention of new technologies specifically designed for the communities we work with, we hope to better understand the needs of a vast and largely ignored population, advance the state of the art in computer science, and contribute to the global discourse on ICTD. In the end, we hope to help people throughout the developing world meet their needs and aspirations.

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