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Mobile Collaboration: new opportunities

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ABSTRACT

Mobile technologies offer new opportunities for children educational activities in that they can beused across different locations and times. Naturally some instances of mobile technology use will necessitate or be enhanced by, the sharing of information.Social interaction is important for sharing ideas, constructing shaping understanding and fundamental for educational development. However the physicalsize of mobile technologies presents interesting challenges when designing for collaborative activities.When designing mobile technologies the importance of collaborative tasks has often been overlooked. The replacement of low-tech artifacts with digital devices, for supporting multiple users, can inhibit the shareabilityof information. We present three projects where mobile technologies have been used as part of a larger mixed reality experience. Novel technologies were used to support children collaborative activities in storytelling, an adventure game and during an outdoor fieldtrip. Interaction with mobile devices within each project is reviewed and the authors highlight important considerations for their design and use across multiple contexts.

Keywords: Interaction, learning, mixed reality, mobile devices.

1. INTRODUCTION

While applications of mobile technologies are often focused on personal usage, within this paper we explore the use of these technologies for co-present collaboration .In many everyday domestic, workplace and leisure settings people use their own mobility and the mobility of arte facts to coordinate their collaboration with one another. So far, however, many of the technologies, which have been designed specifically to support existing collaborative activities, have in fact altered the nature of this interaction, for example, by constraining users to completing tasks at their desk .New technological developments in mobile, embedded and pervasive devices provide designers with an opportunity to better support existing forms of collaborative work, by providing the user with additional computing capabilities, yet delivering this through a ubiquitous channel. Whereas a standard PC would physically limit the task to a fixed physical location, mobile technologies allow users to move around whilst simultaneously accessing information from the digital and the real world. Introducing novel technologies into a collaborative context of use without designing to specifically support these activities, however, can inhibit co-present access to digital information. By simply providing the user with a mobile or embedded computer-based version of an existing arte fact, the way in which users access and share information may be drastically altered. The nature of creating and displaying information using a digital tool will change the process of interaction with people and the environment. Mobile devices have the potential to integrate with other learning activities and materials in the environment .Devices can connect abstract information with physical spatial information. This can enable activities to be situated in a relevant physical space, where the space that one is engaged in includes the device but is not limited to the screen .Mobile, palm sized computers presents new opportunities for learning. Mobile devices have the potential to augment physical activity spaces and enable frequent, integral computer use rather than the occasional and supplementary use of desktop computers. As Roschelle and Pea suggest, this shift may be especially appropriate in cases where there is a high student to computer ratio, and children and teachers must relocate to a particular computer lab in order to make use of the technology. Making the learning process an interactive and collaborative experience is beneficial from a pedagogical perspective. Group work with young children is well established in British schools and research in psychology and education has demonstrated clear benefits of collaborative learning activities in a variety of domains for young children. However, collaboration and learning will only occur if the technology is designed to fit within the context of use for which it is intended. With an inappropriate design, a mobile interface may equally prove to be a barrier to learning. The work reported in this paper involves children aged 7–11 years. Whilst some individual activities occur during classroom learning, at this age education is a fundamentally social activity. In UK primary schools (ages 5–11), one class session may involve several reconfigurations of individual, small-group and whole class teaching. Group work requires relevant skills such as planning, negotiation, tolerance and the ability to listen to others. While mobile devices are being designed and evaluated as personal and lifelong learning devices we focus on mobile devices as collaborative tools. Education-based computer systems are traditionally designed as ''single-user'' systems. Work has been carried out to extend the desktop for use by multiple users and analyses have examined its influence on collaborative styles of behaviour. Use of mobile technologies are of growing interest for childrens play and learning; however, there is still relatively little understanding of the ways in which mobile technologies might be designed to best support co-present collaboration. Nonetheless, as Danesh et al. (2001) suggest, the mobility of these devices opens up the potential for childrens group collaboration .Rather than being limited to working with an allocated partner at a desktop computer, children can move around, interacting with many other children and in differing environments. Inkpen et al. Examined the importance of mobility using questionnaires to examinechildren preferences for where they would like to beable to interact withcomputers, and found that thesecond most popular response was outside (with the first being in their bedroom). For the abovementioned reasons, we have becomeinterested in designing collaborative mobile learningexperiences. Unfortunately, a key restricting aspect ofcurrent handheld devices on collaborative activity is thelimited size of the screen. ''It may be that the maintenanceof shared attention will be more problematic with smaller screens'' .Others have tried to solve the problem of small displaysin mobile technologies in various ways. Forexample, the augurscope is a device consisting of a wheelmounted screen combined with position sensors, whichbetter affords collaborative viewing due to its physicalsize and design. However, small screen size does not have to be, andindeed is not, a barrier to collaborative work. As shownin the examples described in this paper, there are wayswe can design so that children can collaborate around asmall device by paying attention to the detail of theinteraction taking place. Small changes in the

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design anduse of the device can enable pairs to share information.While within this paper the authors focus on thedesign and use of mobile technologies, the projectsconsidered integrated mobile computing within largermixed reality experiences, where tangible, mobile andubiquitous computing are combined. We draw on ourevaluations of mobile devices from three key projects onchildren playing and learning, and make recommendationsfor designers of how best to support these typesof interactivity.

2. NOVEL TECHNOLOGIESFORPLAYINGANDLEARNING

We review three examples from Kid Story and Equator ‘‘Hunting of the Snark’’ and ‘‘Ambient Wood’’ projects that focus on children playing and learning. These projects designed and implemented novel forms of technology under tangible, mobile and ubiquitous computing themes. Each project aimed to support some form of co-present collaboration through technology use, although individual project objectives varied widely. In this section we describe the main aims and objectives of each project, and the reasons why collaboration was important for each.

2.1. Collaborative story telling in kid story

The KidStory project aimed to develop technologies that facilitated children working together to share ideas, andco-construct stories. Technologies were developed to support the use of pictures, models and role-play within classroom storytelling activities. Technology design and evaluation was firmly grounded within a primary school with children aged 6–7 years. Tangible technologies were designed to support groups of children in the creation and re-telling of stories .Children created and re-told stories using a software package called KidPad, which enabled children to draw and use scaling and link-based zooming to navigate around their stories. By scaling-up interaction with this software to a room-sized experience, the project explored the potential of novel forms of technologies to support pairs, small groups and entire classes. Tangible technologies, which were both graspable and touchable, were combined with physical or movement- based interaction sensors. The technology, once set up, was fixed to a specific location, although the equipment could be taken away and installed for each session of use. The children could freely move around the ‘‘interactive space’’ but not outside of it. Mobile PDAs (Palm Pilots) were used to create sections of the story, which could then be uploaded and integrated into the overall story. An iterative user-centered design approach was taken to designing, testing and refining prototypes throughout the three-year span of the project. Here we focus specifically on the use of the mobile devices within one storytelling configuration.

2.2. Collaborative exploration in the hunting of the snark

The Hunting of the Snarkwas a technology augmented children adventure game for pairs of children aged 7 to 8 years. The aim here was to encourage playful learning through developing a novel environment that engaged children in collaborative, exploratory and reflective activities. Experiencing the ‘‘Snark’’ in pairs encouraged joint discovery, discussion and assisted in eliciting children reactions and thoughts. At different stages of the game children entered different ‘‘technology installations’’ (rooms) where they could find out about a mysterious ‘‘Snark’’ creature .This experience was based within an aesthetically augmented laboratory, and each of the installations that made up the game was fixed; the children moved from one station to the next. One of the first activities was ‘‘snooping’’, where a mobile PDA (iPAQ) was used to track particular objects in a treasure hunt style game. Virtual representations of real objects appeared when the user was physically close to the object. A one-day experience enabled four pairs of children to take part in The Hunting of the Snark. Our observations are based on video-recordings of this event around the use of the mobile device.

2.3. Collaborative discovery in the ambient wood

The Ambient Wood project used mobile and ubiquitous technologies to augment children discovery of an outdoor environment. Woodland was augmented to enhance a field trip, allowing students to interact with their environment, and collaboratively construct understanding of the habitats and interdependencies. One of the objectives of this project was to design technologies that did not take away from the users enchantment andimmersion within the natural environment, but helpedthem to explore and interpret their discoveries throughbringing the far to the near and making the invisible visible. The experience enabled pairs of 10 to 11-year-old children to explore different habitats within a wood. Mobile technologies were used for taking measurements of light and moisture at different locations within the habitat. The outcomes from each measurement were displayed on a PDA (Jornada) in pictorial format .Mobile devices were also used to receive location specific information. As the users explored the woodland habitat, their positions were tracked. When they reached specific locations, visual and audio information was sent to them via speakers in the habitat and their PDA. Analysis of technology use .The primary source of data was video recordings of the experience. These were analysed in combination with notes from direct observation. Due to the mobile nature of many of the tasks, and the requirement of the authors to take other roles in the activity (lead the task, set goals, ask the children about their experiences) it was not always possible to rely on direct observation alone. The authors directly observed at least one full run-through of each experience. Each of the experiences described above were video recorded and analysed by the authors. Our approach was to view the videotapes repeatedly with our main focus being how the groups or pairs of children used and collaborated around the mobile technology they were provided with. We viewed each occasion where the children used their technology to show something to their partner, to share information with their partner or to support the construction and shaping of ideas. We were interested in how similar types of technologies implemented in subtly different ways for distinct purposes affected collaborative behavior. We stress the importance of viewing the videotapes with multiple viewers to provide multidisciplinary objectives over behaviour interpretation and to decrease the tendencies of seeing what one is conditioned to or wants to .Identifying how these novel forms of technology may support co-present collaborative activities, we aim to provide guidance to inform future iterations of technologies both within projects, and on a more general level. With each individual project we have usedour evaluations to guide the design of individual technologies. However, when reflecting upon the set of projects as a whole, many of the issues identified with respect to particular types of activity are common across all three domains.

3. MOBILE DEVICES

Similar styles of technologies were used within all three projects to facilitate mobile interaction, but were used for different purposes and required various modes of interaction. In KidStory, children created the content for their mobile digital drawing pad (based on a PDA) using a pen, and could then send this to be uploaded into their story, which was then projected on a large screen. In the Snark experience a modified PDA was used to ‘‘snoop’’or hunt for physical objects that were hidden throughout the real world environment, and these were displayed as virtual representations. The dynamic display enabled a treasure hunt style game to take place. In Ambient Wood the children used two mobile devices in combination. One device measured moisture and light, and the other displayed the readings obtained. Additionally, the same display device triggered visual information dependent upon the user’s location within the habitat. Location-specific information was sent to the display when the user found themselves in particular locales. Although all of the physical devices used had similarities at a surface level (all were modified PDAs), small differences in their design and use resulted in distinctive patterns of collaborative behavior .The mobile devices supported two main paradigms of use. Interactions were either performed between the user/users and the device, or interactions were location dependent and reactive to their position within the real world (determined by where the user holding the device moved to). The following lists present examples of each paradigm.

- Interaction between user and device: drawingpictures in KidStory, observing the continuous location-based signal in Snark, triggering measurements and changing measurement mode (light or moisture) in Ambient Wood and observing discrete location-related signals in Ambient Wood

– Location dependent interaction: signals received dependent upon user location with respect to physical objects in real world—Snark, measurement reading dependent on real world conditions of each location in Ambient Wood. Specific locales within habitat triggered additional, location-related, information in Ambient Wood. These different forms of interaction are key, as they fundamentally influenced how ‘‘shareable’’ mobile technology use could be, as described in the following sections.

3.1. Drawing in kid story

Within the KidStory project digital drawing pads facilitatedinteraction, but were not reactive to the users Whereabouts. The devices were designed to be used primarily by an individual but they were also able to share their contribution to the story by uploading them to the large screen and therefore making them available to the whole group. While the physical size of the mobile devices allowed children to draw sections of their story individually, they could

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easily move around with the device. This enabled them to share information about their drawings with others. They often moved to sit next to other group members and as they worked on their drawings they discussed different elements of their pictures .In order to share their contribution with the whole group they uploaded it to the large screen display. Each child was therefore able to contribute to the creation of the joint story. The use of PDAs for input enabled children to switch smoothly between individual, paired and whole group activity. ''The integration of relatively cheap, simple wireless devices together with physical arte facts and spaces (including displays) creates interesting opportunities for seamlessly distributing learning activities between digital and physical worlds''

3.2. Snooping in snark

Whilst searching for objects the Snooper displayed cross hairs and ''targets'' which needed to be lined up into the centre of the display. The user held the display in their hand and moved about the space searching for objects. The display continually changed with the child movement and meant that they had to constantly monitor the display in order to locate the object. The children can explore the physical environment searching for objects using the handheld computer. The Snooper alerted users to the presence of physical objects via a visual or audio cue. Thus the Snooper acted as both an input device (for searching) and an output device (displaying results). Digital visual representations of the real physical objects were shown when the user was in a specific location, except on one occasion when sound was used to represent a physical object in the shape of a musical note requiring the user to constantly monitor a detail visual image that was responsive to their location made information sharing a difficult task. In addition there was a system requirement for the Snooper to be held so that the display was always parallel with the ground. The level of visual concentration required by the child holding the Snooper combined with the devices sensitivities made it difficult for two children to use the device. Four children working to re-create a story they were studying in class. The children are drawing elements of the story using handheld computers. In this image they share their drawings on the handhelds before uploading them into the story on a large screen display simultaneously. We observed that the different pairs adopted different patterns of working. Some of the pairs took turns, although the child in control of the Snooper always took charge of the activity. In order for the children to share information on the display the child with the device had to stand still. As the main process of searching for clues depended upon the child moving around the space this was not easily done and so the process of searching for clues was a predominantly individual one. This meant that their partner took a less active role in snooping, either by following the child with the Snooper (but having little idea of the visual feedback transmitted to the device) or joining in with the real world object search and collection once the virtual object had been detected. The facilitator frequently attempted to encourage a more collaborative approach to working through instructing the child with the Snooper to stand still so their partner could see the display, and telling them to wander around together so that both could see when objects appeared. The child without the Snooper is unable to view the screen whilst they search for objects.

3.3. Measuring in ambient wood

During the Ambient Wood experience pairs of children shared the use of the probe and mobile device on which moisture or light readings were displayed. They also used a walkie-talkie (WT) to gather information from, and report back to, a remote site. The child with the WT was clearly aware of their partners' location within the space, and from their physical actions it was obvious that the child with the measuring device was takingreadings when s/he was crouched on the floor, stickingthe probe into the ground. Children are taking moisture measurements around the wood.As the children were not often physically very close to one another, the mobile display was usually only within one childs view. However, information was displayed on the PDA only at discrete moments. Once a reading had been taken, the same image would stay on the display until the next reading was taken or another message was displayed. Although measurements were taken regularly, the partner with the WT was able to come up to the ''measurer'' and enquire about the readings periodically, or if they spotted that their partner was in a new area where the readings might be of particular interest. The mobile display was then often shared between both children, and could be passed around or angled towards them so that they could see. Children are exploring the physical environment searching for objects using the handheld computer. When they are in the vicinity of an object the handheld displays a relevant image or sound. The child with the Snooper concentrates on the image on screen, while their partner also tries to view the screen. The child without the Snooper is unable to view the screen whilst she searches for objects. Children are taking moisture measurements around the wood. The physical position of the child taking measurements indicates to their partner the activity that is taking place. Children have taken a measurement with the probe and are now viewing the resulting visualisation. Images displayed can be shared as they are only triggered in certain locationsthe probe and are now viewing the resulting visualisation.

3.4. Location triggered habitat information

In Ambient Wood In addition to this, information was displayed on the mobile display device when the user entered one of three specific areas of the habitat. Again, the visual information was transmitted as a discrete event and would stay displayed until another locale was visited or a measurement was taken. This visual information was accompanied by sounds that originated from speakers placed within the wood. It was clear that the audio information was inherently much more ''shareable'' than the visual information provided. It was equally available to both children, and their facilitator, and provoked discussion as to the meaning of the sound. One of the aims when designing the Ambient Wood experience was that the technologies should augment the user's experience of the real wood and should not engross the user in technology. By delivering occasional information (rather than a continuous flow of information) through the mobile display this was enabled. The children were not ''searching'' the space for information, but this was delivered to them at specific points. As this was a surprising event the child receiving the message would call their partner over to see the display. The use of simple representations meant that information could be communicated quickly and easily.

4. MOBILE COLLABORATION APPS

4.1. Drop box

This file management app lets you transfer and access files from any computer or mobile device running Drop box. Drag and drop files into the 2GB of free file storage. Access those files from any device running Drop box. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.2. Google maps

Along with its classic map application, Google Maps now contains Google Latitude, a geo location feature. It enables you to share your location with others, such as co-workers or clients, as well as see their locations. Check in at places to let others know you've arrived. Share, set, or hide your location at any time. Use the GOOGLE BUZZ layer over Google Maps to post real-time geo tagged updates and collaboration dialogue among team members. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.3. Meebo IM

Chat on multi-protocol instant-messaging networks, including AIM, MAN, Yahoo!, MySpace, Google Talk, Jabber, and ICQ. Use a Meebo account and your IM history will be saved for you to access from any computer. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.4. Box

Box is a mobile app to manage documents, media and all your content in the cloud at BOX.NET. Share files and folders with web links. Sync files to Box. Access Box files on your desktop with enhanced collaboration with Business account. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.5. Quick view

The QlikView app can take your data and create dynamic charts and graphs. Magnify a particularly interesting piece of data and view the information both in portrait and landscape mode. When you're finished editing, a one-button interface makes emailing simple. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.6. Mango suit mobile
MangoSuite Mobile is an app for the online MangoSuite business collaboration platform. The app covers the major features of the platform, including enterprise microblogging, IM/group chat, group conference calling, document management, personal and team task management. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.7. Yammer
Yammer is a private, secure social network for your company. Yammer lets you connect with your coworkers to collaborate, share ideas, and be more productive. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.8. Quick office
Create, edit, access and share Microsoft Office files. Display presentations in slideshow mode, or on external monitor. Edit across entire documents, presentation slides, or spreadsheets. Remotely access and manage files, with convenient access to cloud service providers, including MobileMe, Dropbox, Google Docs, Box.net, Huddle and SugarSync. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.9. Podio
This mobile app gives you all the core functionality of the Podio web platform to create and to collaborate with your peers. Customize your mobile screen with all your favoritePodio apps and spaces. Create app items from your mobile device for everyone to work on. Edit existing apps. Follow and comment on activity in your streams. Create and delegate tasks, and track them. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.10. Orchestra to-do
Orchestra is the to-do list that's connected to everyone you works with. It not only helps you organize what needs doing, it also helps you communicate with others to get things done. Orchestra lets users assign tasks to themselves and each other, and to chat about them. It accepts voice or text input, as well as emails. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.11. Signals campfire
This is the official mobile app for CAMPFIREa group-chat tool. Campfire lets you set up password-protected chat rooms in just seconds. Invite a client, colleague, or vendor to chat, collaborate, and make decisions. Share text, files, and code in real time. Save transcripts so you don't forget. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.12. Group me
Send group messages to your real life network. Start groups with the people already in your contacts. When you have a weak connection, the app can switch you to SMS so you'll never miss a message. Every group gets a unique number for conference calling. Add your location to any message you send, and see all the group members on a map. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.13. Jumvo
Jumvo is a group-messaging app that lets you send voice messages as casually as texting. Jumvo lets you exchange voice messages with Facebook friends anywhere in the world. Engage group conversations with multiple friends. Receive a push notification whenever a voice message is received.

4.14. Fuze meeting
With the Fuze Meeting app, you can host a video or audio meeting from your smartphone. Fuze can call participants into the web conference. Features such as session recording and site branding are available with upgrades. Apps are available in Android, BlackBerry, iPhone, and iPad.

4.15. Show document
This app lets you view and participate on mobile meetings and real-time document collaboration through Show Document. View session content, web pages, shared screens. Exchange text chats with participants. Apps are available in Android.

4.16. Google translate
Translate text into more than 50 different languages. Try the new "conversation mode" in English and Spanish. Speak a phrase to be translated, and then tap the "Enter Conversation Mode" link at the bottom of the screen. Tap the conversation bubbles in either language to quickly translate what you're saying. Apps are available in Android.

4.17. Sugarsync
With the SugarSync app, you can synchronize your files across multiple computers. Back up files to secure cloud storage. Automatically sync data between computers and devices. Easily manage team and groups with pooled storage. Set storage limits per user.

5. DISCUSSION
We have described the collaborative behavior fromthree projects where similar mobile devices, used in subtly different ways, have promoted different types of collaborative behaviours. In both the Kid Story and Ambient Wood experiences the children without the mobile device had their own tasks to conduct and role to play in the activity. These contrasts with the snooping activity where both children were attempting to uncover physical objects using a digital guide. Small mobile devices do not easily afford multiple users viewing their displays and they seem to best support more co-operative styles of working when partners have their own activities to complete, but come together on occasions to share digital information. As it was difficult to share information using small devices, the design of this information is extremely important. Within the Snark experience the displays represented very visually complex and continuously changing pictures that did not easily afford sharing. In Kid Story individuals controlled the information on the display, choosing when to share it with others. In Ambient Wood, the display consisted of still, stable and simplistic pictures. As the display was only changed or updated occasionally throughout the experience the children were able to share this information with their partner. This practice of occasional sharing of mobile information could be enhanced by the more effective use of sound, as a way of indicating to both parties that some information is available of interest to them both. Within the Ambient Wood experience we observed that audio information was equally available to all participants and could be used to co-ordinate activities distributed throughout a space. When the interaction between user and mobile device was reactive to the user's position in space then thisaspectof the interaction seemed to be clearly understoodby the partner without the device. In Kid Story when a child was uploading an image from their mobile device to a large screen display there was visual and auditory feedback. The visibility of the child's action when moving towards the large screen display encouraged the other children to attend to the picture. This worked especially well within Ambient Wood as both partners had their own tasks to complete. It was clear what the partner with the measuring probe was doing from their location and body position and so they could catch up with each other if they were interested in specific outcomes or readings from a particular area.

6. CONCLUSION
We draw three key general conclusions related to supporting co-present collaboration with mobile devices from our work thus far. Firstly, our analysis of collaboration highlights the importance of occasional well-structured information rather than a continuous flow of information. It is often assumed that having the potential for continuously available information means that information should be continuously available. With a smaller, more punctuated delivery of information, children were able to attend to the environment or the collaborative task at hand, without having to monitor the screen continually.

It is therefore much simpler for them to interweave the digital information into their ongoing collaboration. Appropriate feedback such as a sound prompt can be used to convey the delivery of important information when attention to the content is needed. Secondly, within Kid Story we began to explore the use of beaming as a collaborative activity with handhelds. Devices can communicate directly by infrared beaming. This enabled children to beam their drawing to a specific person via a physical gesture. Children developed part of an image and then passed it on to someone else in the group to add more detail and so on. In parallel with the implication that delivery of information should not necessarily be continuous, we would like to suggest that collaboration with mobiles does not have to be closely coupled. Indeed, interweaving closely and loosely coupled collaboration may well prove a future avenue for mobile experiences. This form of collaborative activity has not been explored so far in the other two projects but may be another potential avenue for encouraging collaboration. Finally, the design of the mobile device may enable collaborators to be aware of the state of the information through visibility of action (e.g., placing your moisture probe in the ground indicates a reading). Thus, whilst previous research has discussed the physical affordances of mobile devices for particular activities we would like to suggest that the importance of design lies as much in how co-participants see the device being used as how a participant sees it may be used .Designing with users is very important to these procedures. The design of mobile devices is very task dependent and further iterative design with prototypes would help to investigate interaction around these devices. We are in the preliminary phases of evaluating the use of these technologies for educational purposes but continue to work towards a situation where children and teachers will be able to choose appropriate assemblies of devices to aid learning.

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