Changing Places:
Contexts of Awareness in Computing

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Abstract

By allowing any social institution to structure activity in any place, wireless information services break down the traditional mapping between institutions and places. This phenomenon greatly complicates the analysis of context for purposes of designing context-aware computing systems. Context has a physical, architectural aspect, but most aspects of context will also be defined in institutional terms. This paper develops two conceptual frameworks for the analysis of context in mobile and ubiquitous computing. The first framework concerns the relationship between architecture, practices, and institutions; it directs attention to the complex middle ground in which information services make use of whatever computational resources happen to be in the user's physical surroundings. The second framework is called the capture model; it rationally reconstructs the traditional systems analysis methods, which reorganize work activities to enable a computer to capture the information it needs. Context-aware computing devices that depart from the capture model face a difficult set of design trade-offs.

1 Introduction

Since their earliest days, the predominant discourses of computing have reflected the ingrained Western distinction between mind and body. This Western tradition treats the body, and indeed the whole non-mental world, as something distant and alien. Descartes, for example, portrayed the mind and body as continually at war. Babbage imagined computers as tools for imposing a God-like rational order on the microcosm of the factory (Schaffer 1994). Turing idealized the disembodied mind (Hodges 1983). And Wiener understood cybernetics as a means of imposing order on a chaotic world (Galison 1994).

To be fair, the mind/body distinction has always had some basis in technical practicalities. Robot bodies and senses have been rudimentary, requiring so much controlled regularity in their environments as to make truly autonomous machines impossible. Digital communications technologies have likewise been primitive. It is understandable that the theory and practice of computing have emphasized internal mental processes and stereotyped interactions based on simplified text and graphics.

But this is all changing. Miniaturized sensors and actuators are advancing rapidly, communications networks are becoming ubiquitous, and standards for wireless networking are being established. Above all, technology and design are breaking down the wall that has historically separated computing from the rest of life. A computer terminal effectively requires the user's body to be immobilized, so that images of "jacking in" to a otherworldly "cyberspace" become plausible. Ubiquitous computing (Weiser 1993), on the other hand, weaves networked information technology into the places and activities of daily life. As a result, it requires designers to transcend the mind-body divide and understand the lives of their users more fully.

An innovation that illustrates the trend is Bluetooth (Miller and Bisdikian 2001), an emerging standard for short-range digital communications. As a philosophical matter, Bluetooth is important because it initiates communications between devices based on their physical proximity. Whereas a conventional computer interface requires the user to have visual and mechanical access to the device, a Bluetooth-enabled interface is no longer located on the physical surface of the device. A Bluetooth device can have an "interface" that interacts with other devices that happen to be nearby, even though it is embedded in an appliance, a machine, or a wall. And whereas a conventional wireless device operates through a centralized service that locates it in a global coordinate system, Bluetooth devices interact with one another indexically. A wireless device might reason, "I am located at (X,Y) and you are located at (X,Y), so we must be near one another". A Bluetooth device would reason, "we're both here (wherever that is), so let's do business". This reasoning by proximity is useful from a technical perspective because comparing global coordinates requires a high degree of accuracy and allows the centralized wireless network to track individual devices (and thus their owners). By grounding interaction in geographic locality, Bluetooth invites a style of design thinking that is likewise grounded in embodied (inter)action.

I want to spell out the consequences of this technical and philosophical shift for the way we think about the architecture of the built environment. This effort to rethink architecture, of course, is not entirely new. Researchers in human-computer interaction (e.g., Harrison and Dourish 1996), geography (e.g., Curry 1996), and philosophy (e.g., Casey 1993, 1997) have long been accustomed to thinking in terms of the concept of "place", understood as a historically accreted complex of practices and meanings, as opposed to "space" in Cartesian coordinates. I want to take this analysis further by investigating the relationship between architecture and human institutions. It is only when we analyze this relationship, I want to argue, that we understand what it means for a computer to be aware of its context.

2 Architecture, practices, and institutions

Let us begin with a deceptively simple phenomenon: the cultural flap over cell phone etiquette (Katz 2000: 15-16, Wadler 1998). For all the passion it engenders, cell phone etiquette is only marginally a political issue; the only serious policy proposals (at least so far) concern the use of cell phones by drivers. For the most part, public discussion of cell phone etiquette is simply a matter of collective thinking-out-loud: mass-mediated griping that creates a reflexively shared awareness of the issue throughout society. Yet even though the issue of cell phone etiquette may be comparatively trivial on its own, it portends greater problems later on.

To see why, consider a simple commonplace event: a cell phone whose ringing disturbs a performance in a theater. Theaters have always dealt with noise, such as the coughing of sick people and the crumpling of candy wrappers. But these disturbances have been endogenous: they arise from the actions of people who are located within the physical space of the theater, and who are subject to the moral order of the place. Theater performances have historically been resistant to exogenous disruptions, and the theater building is designed to make such disruptions unlikely.[1] The theater as a building reflects a set of social relationships: between the players and the audience, those who have been admitted into the seating areas and those who have not, the people with the expensive tickets and the people with the cheap tickets, the bartenders and the intermission drinkers, and so on. The theater assigns every activity to a place: dressing in dressing rooms, performing on the stage, watching from the seats, buying tickets in the lobby, and so on. In fact, the word "theater" is ambiguous: it refers to the building where plays are performed, but it also refers to the institution that defines all of the social roles (audience, performer, usher, bartender, ticket clerk) and the activities that go with them. The architecture itself does not guarantee that everyone will behave themselves according to their assigned position in the theater's social order, but it does provide structural resources and constraints for the socialization process. Everyone plays their part in this institutional drama, and so the play can get performed.

Cell phones loosen this mapping between activities and places. The theater as an institution defines a small set of relationships between people, but a cell phone call can connect a theater-goer to anyone at all: an employer, a reporter, a dental office administrator, or a fellow club member, among many others. Each of these relationships comes with its own repertoire of activities; some of these activities can be conducted over the telephone, and others can at least be plotted or chewed over. Of course, not every place restricts its participants as tightly as a theater. A restaurant, for example, can provide the setting for a business negotiation at one table and a romance at another. Nonetheless, each conversation in a restaurant is shaped to the sensibilities of the place. Cell phones, however, shift the basis of social order from the constraints of the place to the local negotiation of an interactional order that can be connected to anyone and anything. Parties meeting for a restaurant meal, for example, might develop a custom of returning phone calls before they settle down to conversation.

New technologies of connectivity may push these trends much further. For all their power, cell phones embody a primitive model of connectivity: users are interrupted and then connected synchronously. The connection is all-or-nothing, with voice mail and a few other features such as call waiting in-between. But other protocols are easy to imagine, and even current-day technology allows people sitting in a cafe or conference hall to keep an eye on the ball scores, the stock prices, and the kids at day care. In these cases, connectivity is continuous but peripheral. It is also

[1] Exceptions do exist, such as the notorious problem of passing subway trains disrupting films at the Angelika Film Center in New York. Many theaters are also susceptible to sirens from passing emergency vehicles.

reconfigurable, as the user selects different channels or display modes. This model is familiar enough from mass media such as radio and television playing in the background, but it can also be generalized to any relationship that can be meaningfully wired. As all of one's relationships can be continually present, divided attention becomes the rule. The mapping between activities and places will dissolve, and everyplace will be for everything all the time.

We need a conceptual framework to analyze these phenomena. For present purposes, three levels will suffice: architecture, practices, and institutions.[2]

* "Architecture" means the built environment (and not the architecture of computer systems). I will focus on fixed structures such as buildings, walls, hallways, doors, and windows, but any physical object is included (a kitchen appliance, for example) if it is customarily confined to a single place.

* "Practices" means the ensemble of embodied routines that a particular community of people has evolved for doing particular things in a particular place. On a micro scale these practices might include the customary greetings and debriefings that a married couple engage in when they arrive home from work. On a macro scale they might include a society's ways of attending the theater. The term is intended to index so-called practice theories of anthropology, for example Bourdieu (1977), Lave (1988), and Ortner (1984).

* "Institutions" are the persistent structures of human relationships, or put another way the ensemble of social roles and rules that constitute those relationships (Commons 1924, Goodin 1996, Knight 1992, March and Olsen 1989, Powell and DiMaggio 1991). Examples of institutions include the medical system, the research university, marriage, intellectual property, the English language, the stock market, Halloween, parliamentary procedure, norms of public politeness, and the rules and conventions of driving on the highway. Institutions create a categorial framework for practices, or to use North's (1990: 3) metaphor, the rules for a game.

These three levels of analysis may be understood as a sandwich. Architecture and institutions, once established, are relatively long-lived and impersonal, and they

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[2] Much more complicated analytical frameworks would be required, of course, to support real design activities. One of the most sophisticated is the Locales Framework (Fitzpatrick, Kaplan, and Mansfield 1996). Fitzpatrick, Kaplan, and Parsowith (1998) use this framework to analyze the spatial organization of work activities in buildings. Leading examples of institutional analysis of computing include Danziger, Dutton, Kling, and Kraemer (1982) and Mansell and Steinmuller (2000).

provide the boundary conditions for the constant negotiation and evolution of practices. Buildings typically conform to standardized types because of the way they map the institutions they house (Markus 1993; Mitchell 1995: 48, Panofsky 1957). The theater provides an example: the institution defines a set of social roles, and the relationships among those roles are mapped onto the customary structure of the building. Nearly every building is designed with an institution in mind: the family home, for example, with its distinction between the master bedroom and the other bedrooms; or the hospital with its specialized places for patients, nurses, staff meetings, visitors, administrators, and maintenance workers.[3] Buildings thus posit identities -- roles that we live out both subjectively and through bodily engagement with the people and things of particular architected places. Hospitals make us into patients, courtrooms into jurors, restaurants into diners, and so on. Having been defined in this way, we certainly retain a broad freedom of action. But we conceptualize and strategize our action upon a terrain that the institution has created. This linkage among institutions, architecture, and identity is what Foucault (1977) means by power, and it stands to reason that most social practices have been heavily constrained by the architectures and institutions between which they are pinned.

To be sure, architecture is not completely immutable. Buildings do evolve to some degree through the impact of the activities within them (Brand 1994). Some building types are designed to be reconfigured (Fox and Yeh 2000); a hotel ballroom, for example, can be partitioned to accommodate parallel tracks of an engineering conference, and then the partitions can be removed and the decorations and lighting changed to accommodate a high school prom in the evening. The same space is made to support different institutions at different times; in doing so, it arguably becomes a different place. But this has long been the exception.

New technologies complicate this picture. If institutions and architectures have historically been clamped together, imposing a strict mapping between activities and places, now the clamps are slipping. Institutions are less tied to places and activities are becoming more fluid. New technologies of continual presence allow any institution to structure activity in any place, and so the participants in activity must increasingly negotiate the cross-cutting demands of their various institutional involvements (cf. Kolko and Reid 1998). For example, mobile payment technologies bring the institutions of banking and commerce to every place. Wearable medical devices with wireless data links liberate the institutions of medicine from the clinic

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[3] Exceptions do exist. Flanagan (2000) describes the mixture of building types in a new generation of hospitals. And in small traditional cottages, such as those of the mountains of Norway, all activities are necessarily conducted in the same space.

so that patients can maintain constant, real-time relationships with the medical system wherever they go.[4] Family members can stay in constant touch during the day, and extended families can remain continually aware of one another despite being geographically spread out. Each institutionally organized relationship acquires an increasingly complex informational structure, and Poster (1996) observes that the databases that capture this information have the potential to bind individuals even more tightly into their institutional roles. Yet at the same time, the pervasive cross-cutting of institutions also tangles the lines of power, creating a complicated landscape of everyday practice that the culture has only begun to explore.

This strange new landscape will presumably have consequences for the distribution of activities in space, as well as for the structures of both architectures and institutions. Sassen (1991), for example, argues that new information and communication technologies loosen the bonds that have connected finance people to their investments, thus freeing them to move to global financial centers to engage in the face-to-face negotiations that complex modern finance requires. These technologies also allow financial organizations to shift their back-office operations to lower-cost regions of the world. As a result, world cities such as New York increasingly consist of financial people, together with those support services, such as restaurants and cultural activities, that still require physical proximity.

Mitchell (1999: 72-82; 2000) generalizes this argument, observing that new technologies loosen a wide variety of bonds. The result, in most cases, is not that individuals float free of all spatial attachments. Some bonds remain, and those remaining bonds increasingly determine the geographic distribution of activities. Mitchell thus optimistically predicts that the electronic weakening of bonds between individuals and their workplaces will bring a return to mixed-use urban areas, whose lifestyle advantages create bonds of their own.

At the same time, the category of place has a deeper institutional resonance than these reckonings of bond-strengths can capture. Burkean conservatism, for example, assigns people to "places" in a social order. The traditional mappings between institutions and architecture have historically ensured that social orders are mapped onto the places of the built environment. But an increasingly democratized society erodes the more artificial distinctions, and the built environment evolves accordingly. How would the always-on world interact with a resurgence of conservative culture?

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[4] It should be remarked, though, that these devices are limited by the difficulty of sensing on the body during normal daily activity, and by the limitations of current battery technology (Starner personal communication, 12/16/00).

Perhaps the ancient role of architecture in producing social distinctions will be transferred to ubiquitous electronic technologies of surveillance and control, or perhaps the dynamism of the connected society will effectively make it impossible to impose artificial social distinctions in practice.

3 Activities and places

What consequences does the loosened mapping between activity and place hold for the design of context-aware digital devices? (See Dey, Salber, and Abowd (2001 [this special issue]).) For simplicity, let us suppose that every device is attached either to person -- whether worn or carried -- or to a place -- whether embedded in the walls or simply kept in a certain locality (Rhodes, Minar, and Weaver 1999). In the most general case, all of the devices that happen to be located in a given place at a given moment will interact both with one another and, over the Internet, with devices in other places. Faced with all of these many types of potential connectivities, it is a challenge even to define what "context" could mean. If "context" means "place", then a place might have "house rules" that limit the potential range of functionality of devices that are located within in. A theater, for example, might compel all cell phones (and other devices) to shut off their ringers. An airplane might compel whole categories of devices to shut themselves off once it pushes back from the gate.[5] (Of course, establishing the institutional arrangements to standardize and implement such a scheme in a general way would be a formidable undertaking.)

For most purposes, however, "context" must be reckoned in both architectural and institutional terms. It matters, for example, whether a place is a restaurant or a theater, since the activities that occur in those places have a different categorical structure.[6] For example, one might imagine a portable Bluetooth device that, having sensed that it is located in a restaurant, activates the interactional repertoire that is

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[5] Cell-phone jammers are available legally in some countries (Wylie 2000). At least one system is available commercially to enforce house rules on Bluetooth-enabled devices; see <http://www.bluelinx.com/products.htm>.

[6] The categorical structures of the two institutional settings may not be completely different: in both restaurants and theaters one has, for example, customers and employees. As with the case of "house rules" that transcend different sorts of architectural places, the broad categories of customers and employees are found in many institutional settings, and some rules might apply to all such interactions, perhaps with refinements for each particular institution. For the most part, however, we should anticipate that different institutions' categories will be incommensurable in unexpected and insidious ways.

suited to restaurants. Having then detected a Bluetooth-enabled menu, it might inform the menu of its owner's dietary restrictions, and the menu might reconfigure itself dynamically to display only those dishes (and variations on dishes) that fit the constraints. Finding itself in a movie theater, this same device might enable payment protocols that activate when the individual passes through a certain turnstile.[7]

But even these applications presuppose the traditional strict mapping between architectures and institutions. They still reckon a "place" by the set of institution-specific rules that operate there. At another extreme are devices whose operation, while deeply embedded in the workings of a particular institution, is wholly independent of particular places. Examples include wearable medical monitors or portable stock trading devices, or "current awareness" services that monitor a digital library for new publications by the user's professional colleagues. These devices need not be aware of place (except through their ongoing contact with the wireless communications infrastructure), but they exist to maintain awareness of institutional aspects of context. Examples of relevant institutional facts might include the ownership of a stock or a theater ticket, having been placed in the care of a particular doctor, being responsible for particular items of workflow, being targeted for a sales pitch, or having a house in escrow. These institutional elements of context can affect the significance of events and conditions in a wide range of places.

Context, then, has two aspects, architectural and institutional, that may be coupled to various degrees. A continuum emerges. At one end are those applications for which the coupling is very strong, so that architecture and institution map closely to one another. These applications are strongly coupled to a particular place, and a device can register certain aspects of its context simply by knowing where it is. Dey et al give the example of a device that supports conference-goers by figuring out which talk they are attending; this is possible because of the schedule, presumably online and kept up-to-date, that maps rooms and times to talks. At the other end of the spectrum are those applications which depend only on the architectural context or (more commonly) the institutional context. Examples, such as the wearable medical monitor, have been provided above. Between these extremes is a largely unmapped space of possibilities: institutionally organized activities that are loosely coupled to places. And it is in this middle ground that context-awareness becomes most crucial and most complicated. Examples would include activities that, while strongly coupled to the information infrastructure of an organization, can automatically adapt

[7] This example derives from a project at UCLA by Robin Dodge, Sidarth Khoshoo, Paul Miller, and Ping Wang.

themselves to the resources -- scientific instruments, display screens, printers, automobiles, hand tools -- that happen to be available in particular places.

As the mappings between institutions and architectures break down, this middle ground of loosely coupled activities will surely expand. Physical places and things will become more plastic, and thus more capable of playing roles in a wide variety of institutionally organized activities. Space does not permit detailed prognostication, which would probably be impossible anyway.

4 The problem of structure

For all its complexity, this analysis does not adequately explain the relation between context and activity. "Context" is such an all-embracing term that it is easy to underestimate the problem of designing a computational device that could be "aware" of it. Some aspects of context are simple ambient parameters of physics -- such as temperature or noise levels -- and in these cases the matter is not so difficult. Most aspects of context, however, are defined to some extent by the institutions that structure both the ongoing activity and the social relations within which the activity is embedded. For example, a device that is supposed to help people conduct a meeting needs to know the participants in the meeting (as opposed to people who happen to be nearby for other reasons), whether the meeting has begun (as opposed to the smalltalk that precedes the transition to formal meeting mode), which agenda items are being discussed (even though participants may parenthetically anticipate an item or refer backward to one already officially completed), and other categories that are defined by the prevailing rules of order. These are all institutional entities -- without the institution of a meeting they would not exist -- and they are constructed through the moment-to-moment interactional work of the people in the room. The people use the various features of the physical environment as resources in this work of social construction, but it is only through their ongoing, concerted effort that the *place* -- not just a room but a meeting room -- comes into being. A device that cannot participate in this work of social construction will be incapable of registering the most basic aspects of "context" in the ongoing meeting, and yet the very nature of the work is poorly understood.[8] This is the key insight of ethnomethodology

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[8] In his work on "intelligent" meeting rooms, Coen (1998) argues that a strong technological coupling between the meeting participants and the room technology can be avoided using techniques from artificial intelligence. Some useful functionalities can surely be provided that way. The challenge, on the analysis presented here, is whether AI techniques can be used to infer the socially-constructed facts that the room system would need to register in order to provide more advanced functionalities.

(Garfinkel 1984, Suchman 1987), and it is a strong constraint on the design of context-aware devices.

The main tradition of computer system design, however, has a solution to this problem: restructure the activity itself in such a way that the computer can capture the relevant aspects of it. This design methodology, which I have called the "capture model" (Agre 1994), has five stages:

* Analysis. A systems analyst studies an existing form of activity and reduces it to a repertoire of atomic elements -- entities to be represented in a database, institutionally meaningful actions that affect the existence and attributes of these entities, and so on. (See, for example, Whitten and Bentley 1998.) For example, the entities for a library circulation system might include patrons and books, and the actions might include checking a book out, returning it, and declaring it missing.

* Articulation. The analyst goes on to devise a grammar that can generate, and thus represent, all of the institutionally permitted sequences of action. This grammar might draw upon the explicit or tacit rules of the activity, but it is a formal construct in precisely the sense of formal language theory.

* Imposition. The resulting grammar is introduced into the everyday life of the institution and given a normative force. The people who engage in the activity are somehow induced or obligated to organize their actions in a way that can be "parsed" in terms of the grammar. For example, an organization might introduce step-by-step procedures or construct physical barriers such as hallways that channel people from one place to another in a prescribed order. A library might install a theft detection system that, together with a security guard posted near the doorway, prevents books from being removed from the building unless they have been checked out. As these examples suggest, the imposition of a grammar of action can have pervasive consequences for architecture, and indeed it is largely through imposition that the mapping between institutions and the built environment arises.

* Instrumentation. Social and technical mechanisms are installed that parse the activity, whether in real time or in retrospect. This phase may coincide with the imposition phase, or it may follow much later. An example would be the introduction of double-entry bookkeeping, which imposes a grammar upon the handling of money and requires that accounting books record each transaction in a way that can be audited later. The instrumentation of library practices includes affixing bar codes to the books and scanning them (or typing in the bar code number) in the course of each transaction. Instrumentation is straightforward when the

activity is conducted exclusively through electronic mediation, as for example in computer supported cooperative work (Greenberg 1991), because in those cases the grammar of action corresponds directly to the users' commands. But it is typically straightforward in physical environments as well, given that the architecture and practices have probably already been designed to impose the grammar.

* Elaboration. As the captured activity records accumulate, they can now be used for a wide variety of purposes, both good and bad. Examples include surveillance, marketing, publishing, giving advice, evaluating performance, and controlling quality.

The capture model provides a method for integrating computer systems into social systems, but in doing so it exacts a price. Participants in a newly instrumented activity may find themselves filing paperwork, swiping cards through magnetic card readers, communicating in controlled vocabularies, or imposing standardized structures on their documents. The participants may balk at this effort, or the overhead of data entry may degrade their performance, or the system might be used in a superficial way. Political struggles may erupt over issues of surveillance and control. In practice the designer faces a trade-off: the more structure a system imposes, the more functionality it can provide; but the capture of structured information imposes costs of its own. For example, a system for capturing design rationales (Moran and Carroll 1996) can err by requiring designers to analyze their rationales into such fine-grained units that the design process is slowed by the effort of formulating and entering it all. Those fine-grained representations of the design process might be useful for subsequent indexing and searching, or for advanced functions like simulation, but the cost of producing them might outweigh the benefits.

The trade-offs inherent in the capture model are a central challenge for the design of context-aware systems. Designers must choose among three unpalatable options:

(1) confine the system to registering those few aspects of context that are not defined in institutional terms (again, largely physical parameters like temperature), or to those aspects of context that are captured by computerized tools whose grammars of action have already been imposed and instrumented in the activity,

(2) perform the social engineering necessary to impose a fine-grained grammar on the activity and its participants, or

(3) reject the capture model, and instead register aspects of the environment that can serve as rough, heuristic (and therefore fallible) proxies for the institutional variables that are the real objects of interest.

Option (3) is especially common in the literature on context-aware systems, and it bears special consideration. The idea is that institutionally defined states of affairs have approximate correlates that a machine could capture without requiring any explicit cooperation from the people who are involved. Registering the context heuristically can be a reasonable design choice, for example, when the consequences of error are slight. Consider the case of a system that displays evolving selections of information for the curiosity of passers-by (Sawhney, Wheeler and Schmandt 2001). The system uses a camera to observe the heads of passers-by, and a passer-by who is observed to glance at the display is assumed to find an interest in the topic currently being displayed. Such a system can guess at the interests of individuals who might be nearby, but if it is designed conservatively enough then poor guesses will cause no harm except to the long-term reputation of the system itself.

The drawbacks of such a scheme become clear, however, as soon as users wish to exert control over the system's choices. Precisely because no grammar of action has been imposed on the users' engagement with the system, the heuristic nature of the contextual data violates the user illusion (Kay 1990: 199) -- users do not feel like the system is under their control. Even though the system tries to infer user interest by detecting head motions, the designers did not understand these head motions as commands, and they did not provide users with the kinds of feedback that a well-designed command interface provides. Thus Sawhney et al (2001: 16) observed, based on informal experience with their system, that "people ... desire better cues such as audio/visual or text-prompts to enable them to understand the different modes of interaction". Once the users realize that the system's behavior depends on their head motions, in other words, the logic of the capture model begins to take hold. The designers had understood the head movements as context features that a system could register as proxies for humanly meaningful states of affairs (in this case, certain social practices of reading), but it is not possible to detect those meaningful states of affairs with perfect reliability without the user's cooperation. In general, as soon as a context-aware system's choices become significant, the fallibility of its context cues will become problematic for users. Tools for meeting support, for example, will probably fail annoyingly if they are made to guess at socially constructed events such as the start of the meeting or the transition from one agenda item to the next.

5 Conclusion

The picture that emerges from this analysis is complicated and not especially optimistic. Context-aware systems will increasingly be used in activities that fall in two netherworlds: the loosened coupling between activity and the built environment and the outer limits of the trade-off that is inherent in the capture model. The always-on world allows every institution and every relationship to be continually present in every place, but precisely for that reason the very concept of place is going to change. Traditional places created strong expectations about the structure of activity. Those strong expectations were often bad, of course, because they foreclosed options that are now opening up. But they were also good, because they made life simpler. Life is going to be complicated now, and a central task for design will be to make sense of it.

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