The Design Space of Computer-Mediated Communication: Dimensional Analysis and Actively Mediated Communication

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Abstract

As they are for everyday people, the many extant forms of computer-mediated communication (CMC) are potentially overwhelming to researchers and designers. To make sense of the broad variety of current communication technologies and practices and to support generating new forms of communication, we use a dimensional, morphological analysis to develop a systematic account of this design space. This paper motivates and describes the application of these methods of analysis to CMC. Communication through mobile phones and social network services provide examples and a design-orientation. We propose several basic dimensions that distinguish forms of communication. Finally, we detail our ongoing work in analyzing how CMC

can involve active mediation — transformation, synthesis, and influence as constituitive parts of forms of communication. Open issues of methodology, ontology, theory, and design are each considered.

1 Introduction

Technology and communication are closely linked, and we have recently witnessed a simultaneous explosion in distinct communication technologies and associated communication practices. These new technologies have both influenced and reflected dramatic changes in the ways we communicate.

Communication technologies extend our communications over both space and time. For example, mobile phone users globally use text messaging to immediately deliver a short message to another person, who can then reply asynchronously, almost wherever each is. People also use Facebook's Wall[1] (analogous to a whiteboard on a dorm-room door) to send short messages that are addressed to and associated with a particular person, but with a semi-public audience. Text messaging and the Wall, as technologies and settings for communication, have similarities and differences, and these differences influence how they can be and are used. If we want to understand the significance of a communication technology in anything but an isolated way, we should be able to say what these features are in a systematic way.

What we have said so far emphasizes that technological development influences cultural and social practices, but also the reverse: technology underdeter-

[1]Facebook is an online social networking service. See Facebook: `http://facebook.com`

mines adoption, practice, and interpretation. This is the well-trod ground between technological determinism and social construction of technology. The introduction of a new communication technology can shape social and cultural practices, but technologies emerge from and are appropriated within specific situations — both broad historical contexts and individual situations of use. Of all the possible forms of communication, people have created and used some, but not yet some particular others. What are these other, merely possible forms of communication? What features of practices and values determine the very identity of some form of communication — over and above its technological specification? We can anticipate that some of these potential forms of communication will become actual. Some will be slight adaptations of existing technologies and practices, and others will be more radically different than any current or past forms of communication.

In this work, we present our approach to understanding existing communication practices and technologies, bringing this systematic account of the actual to bear on exploring the larger space of the possible. Our focus here is on computer-mediated communication (CMC). We use examples from traditional forms of communication, mobile communication, and communication on social network services (SNS) — Facebook in particular.

2 Method of Analysis

The goal of this ongoing research is to systematically explore the space of possible forms of communication, including their technical realizations, with the goal of

better understanding the technologies and practices we have created and adopted — and also those we have not. This analysis is aimed at description, criticism, and invention simultaneously. Given what we have said above, it should be clear that meeting this goal requires an appreciation of both how the variation in the technology itself explains variation in practice, but also how historically and culturally contingent anticipations, practices, and reactions can shape the identity and significance of the forms of communication.

To make sense of the broad array of existing communication technologies, we systematically organize them through *morphological analysis* (Zwicky 1967; Card et al. 1991). A morphological analysis begins by identifying and defining relevant dimensions that describe and distinguish the chosen phenomena from one another. The chosen dimensions are used to construct a multidimensional morphological box — or *design space* — in which each of the phenomena are situated. In adapting this method to CMC, we are drawing more generally from variable-based approaches to the study of technology (Nass and Mason 1990). That is, rather than orienting to individual artifacts or cultural settings and rejecting the possibily of comparison across them because of a naive form of holism about technologies or practices, we focus on undestanding and invention by studying variations.

The dimensions, or a subset of them, can be organized graphically to chart the design space. In an influential example, the design space of input devices is represented in a diagram that displays a set of relevant dimensions at a glance (Card et al. 1991). These visualization are an important tool in creating the analysis and

applying it to particular problems. These visualizations help designers identify families of related phenomena, choose appropriate values of the dimensions for an invention, and weigh variations. By considering combinations of these dimensions, one can see the limits of existing technologies and practices — identifying holes in the design space of CMC. We use basic visualization of the design space below. In section 4, we sketch a new adaptation of representations of relationships between different points in the design space.

In the next two sections, we address how these dimensions are to be selected and what we should take them to describe. These are interrelated questions: the phenomena as broken into the chosen units of analysis should in general assume a single value for each dimension, and if we see phenomena as distinct and different then they should assume different values for at least one dimension.

2.1 Criteria for Selecting Dimensions

Selecting dimensions that specify the design space to be used simultaneously for analysis, criticism, and invention can be difficult in general, and analysis of CMC presents special challenges.

First, we need a principled way to evaluate individual dimensions. That is, what criteria should we use in deciding whether a particular dimension is optimal for morphological analysis — both in general and also specifically when applied to CMC? Not only does specifying these criteria suggest a decision procedure for constructing the design space, but it helps to clarify what dimensions in a morphological analysis are. The following is an incomplete sketch of some of

these criteria, which can be difficult to formalize.

Morphological analysis is an analysis of form, and the dimensions should describe the form or structure of the phenomena. As applied to human–computer interaction (HCI) and psychology, we take morphological analysis as analysis of dimensions that would be generally appropriate as independent variables in experimental research. For example, we might be interested in the perceived agency of a particular communication medium, but this would not be suited to use as a dimension: it is a dependent variable that, though we would expect it to be predicted by some of our dimensions, will vary with many other factors that are not properly "part" of the phenomena (e.g., chronic loneliness and social disconnection (Epley et al. 2007)). We may wish to theorize about perceptions of agency, rather than operationalizing it into something that can be manipulated, designed, or seen to be part of the phenomena we are distinguishing with this analysis. This is an inexact notion, but it emphasizes in a familiar way that the dimensions should focus on the contribution of the phenomena, rather than the contingent — and also interesting — psychological effects they produce.

Beyond the criteria for evaluating individual dimensions, how should we select a subset of multiple dimensions for analysis?

Some positions in a particular design space may be occupied by multiple phenomena. This indicates that either there is no relevant difference between the phenomena, or that some further dimension is needed to distinguish phenomena that are relevantly different. This should motivate considering dimensions by which these phenomena can be distinguished and evaluating the contribution of these

new dimensions to the analytic and generative value of design space as a whole.

On the other hand, one should expect there to be as yet unoccupied positions of the design space. As long as these positions *can* be occupied by new phenomena, this indicates no problem with the design space. In fact, this is what makes the method generative: these gaps are opportunities for invention and experimentation. This implies that there is nothing problematic about particular dimensions exhibiting multicollinearity over the extant phenomena.

2.2 Forms of Communication Settings

Thus far we have refered to forms of communication as the phenomena analyzed in the design space, but more needs to be said about what we take forms of communication to be and why they are preferable to other units of analysis. In selecting criteria for dimensions and choosing a unit of analysis, we have to account for both the technical characteristics and more social and cultural parameters — the practices, norms, metaphors, settings, and genres that circumscribe the particular communication events we aims to group together as a unit.

There are many alternative views of what the appropriate units of analysis are. Are they media (McLuhan 1963), pairs of encoders and decoders and noise characteristics (Shannon and Weaver 1949), or settings of language use (Clark 1996)?

Individuating these phenomena can quickly get complicated. For example, McLuhan (1963) argued for considering neon lights as a medium, but treating neon writing as another distinct medium. These complications come with the territory, and we do not claim that the identity conditions for our proposal are

preferrable, but individuating the phenomena in a useful way has been a central concern in this analysis. Likewise, individuating the phenomena such that we can select single values for particular dimensions can be difficult, as will be clear in later sections.

Our proposal is to make forms of communication settings, which we will often also call forms of communication, the unit of analysis. *Forms of communication settings* are, or at least specify, sets of actual and possible communication settings that share morphology.

As introduced by Clark (1996), settings of language use are not concrete settings, by categories in a taxonomy of settings — for example, there is the personal, spoken setting and there is the fictional, written setting.[2] We instead define *communication settings* as concrete particulars — individual settings of communication. So a communication setting includes all those particular people participating or in the audience. Though concrete particulars, we consider both actual and possible settings, and both are included in the set specified by a form of communication. What then is the grouping function by which these concrete settings (possible or actual) are grouped into a single form? This groups together as a single unit settings that are not only distinct settings, but the settings differ in some way. For example, the exact number and relationship of participants and other audience members in some particular setting can be abstracted away, so that the form (e.g., a single addressee and a public audience that potentially includes any-

[2]Clark's taxonomy of arenas of language use is, in a sense, two-dimensional, but one dimension is a general categorization that distinguishes settings that are personal, nonpersonal, institutional, prescriptive, etc., rather than describing a single feature or family of features of concrete settings.

one) is not dependent on these details.

3 Some Basic Dimensions of the Communication Design Space

In this section, we describe some dimensions of the CMC design space. Many of the dimensions we introduce here are not new and will be familiar: they are taken or adapted from research in psychology, social science, communication, and human-computer interaction (HCI).

For much of this prior work, serious face-to-face conversation is treated as the basic case, with all others considered derived from or parasitic on it (Clark 1996; Searle 1969). Nonetheless, mediated communication can offer many advantages over face-to-face communication through differences from this basic case (Hollan and Stornetta 1992); in fact, one major result of this analysis is systematic understanding of the desirable affordances of values for particular dimensions not manifest in face-to-face communication. Steuer (1992) takes this approach in defining virtual reality and presence — the experience of "being there". Furthermore, computers make active, strategic mediation of communication possible (Licklider and Taylor 1968; Winograd 1994; Bailenson et al. 2004). For example, computers can transform gestures in virtual reality in physically impossible ways — yielding preferable results for some or all participants (Bailenson et al. 2004). Thus, the properties of a form of communication can have important implications on how the message is perceived and used (cf. McLuhan's (1963) claim that "the medium

is the message").

In the remainder of this section, we describe a small selection of dimensions designed to highlight the salient properties of the range of forms of communication today. Forms of communication involving either mobile phones or a social network service (SNS) play a central role as examples in these dimensions. We have chosen to focus on Facebook in particular for several reasons. First, it is currently a popular SNS worldwide, so its forms of communication are relevant. Second, its forms of communication are also numerous and varied. Finally, many of its forms of communication involve active mediation, as described in section 4.

3.1 Spatial and Temporal Distance

Compared with face-to-face conversation, perhaps the two most obvious differences introduced by technology are that it allows the participants to communicate across different places and times — communication at spatial and temporal distance. This is a familiar family of features to organize the space of CMC or computer-supported cooperative work (CSCW); beginning with Johansen (1988), CSCW investigators have used the colocated-remote and synchronous-asynchronous distinctions in associating and distinguishing groupware.

Our first dimension for forms of communication is ***spatial distance*** (Clark and Brennan 1991): are the participants in the same place or distant places? In face-to-face conversation, though participants are never in exactly the same spatial position, they are often in the same place – sitting at the same table, standing in the same room, walking on the same stretch of a path. Their distance is limited by

how far their voices carry and at what distance their faces and gestures are visible. As with other dimensions, technology can relax this constraint on co-presence: we can mail in a form, telephone a distant friend, and clearly see and hear a musician perform on a big display from cheap seats.

Temporal distance is a bit more complex, and we can distinguish at least two dimensions that constitute it (Clark and Brennan 1991; Clark 1996), some of which we consider here. First, there is the matter of whether one can receive a communication only as it happens, or for some time after that: how quickly does the communication fade, and is there a permanent, legible artifact of it? This is the ***record*** dimension. Second, there is the matter of the reply: how quickly is it possible, easy, and appropriate to reply — including how quickly is a reply generally expected. This is the ***synchronicity*** dimension.

The synchronicity and spatial distance dimensions are used to chart several examples in Figure 1. The chart shows a large bias towards more synchronous communications offerings for the mobile phone, and a bias towards more asynchronous offerings for Facebook. Although there are some more asynchronous forms of communication for the mobile phone, such as text messaging, the social expectations for text messaging make it less tolerant to delayed replies than different types of communication on Facebook.

We classify forms of communication to have a high spatial distance when the recipient of the communication is highly likely to be not co-located with the sender when the message is received. The resulting distribution of forms of communication shows a strong bias towards distant communication. While most mobile

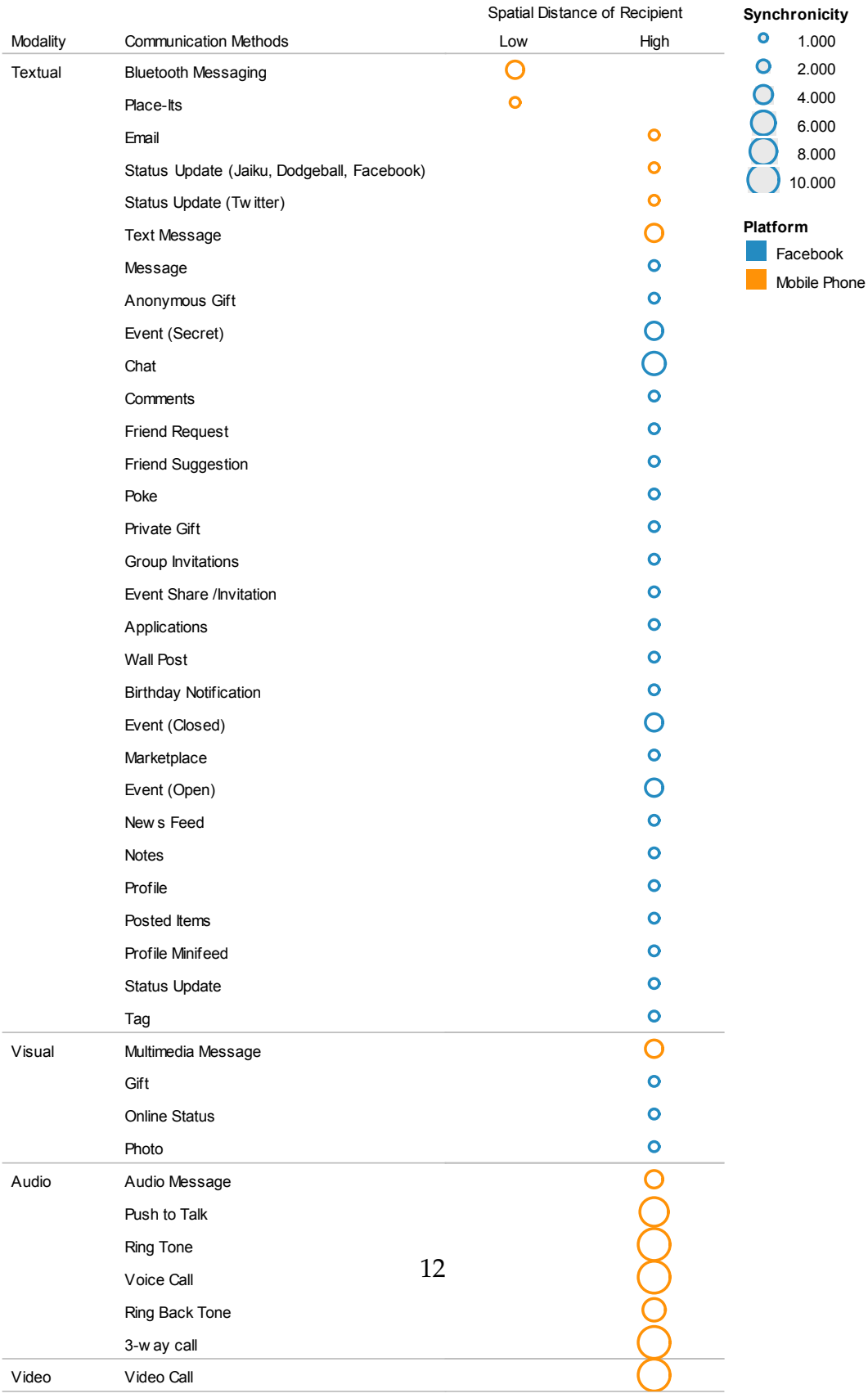

Figure 1: Spatial distance vs. synchronicity. The size of the circle corresponds to a ranking of synchronicity. The larger the circle, the higher the expectation for a rapid reply.

communication technologies are designed with distant communicators in mind, they also include forms of mediated communication that only somewhat relax these constraints: in sending a Bluetooth message (e.g. a cameraphone photograph), the recipient must be within a short distance and must accept the message while still in the place and within a short time. Similarly all explicit channels for communication on Facebook remove the constraint on co-location, but Facebook is also used in co-located communication: people "poke" each other from ends of the same couch, and friends read a new acquantance's profile together.

Receiving a mobile phone call — and the resulting ring tone — is also an interesting incidental form of co-located communication: phone owners set a ring tone, allowing a caller to communicate when they are calling, but that ringtone is also shared with those within audible range of the phone. As for spatially constrained but asynchronous communication, many research prototypes for mobile devices have explored the idea of leaving persistent messages in current location for oneself and others: for example, one can remotely leave "to-do" notes in the places they should be completed (Sohn et al. 2005).

Despite these examples, the gaps in the figure corresponding to low spatial distance raise the question as to whether Facebook or mobile phones could better support collocated communication. As an example, consider a phone that was designed to support collocated business meetings.

3.2 Addressee, Audience, and Identity

When in face-to-face conversation or any other communication, central concerns include with whom one is communicating, and how participants' identities are made available. The former concern is composed of two dimensions in our analysis: ***addressee*** and ***audience***. While addressee defines who the communication is addressed towards (e.g., who is "you"), the audience is the full set of recipients and potential recipients, including side participants, bystanders, and eavesdroppers (Clark 1996).

When one writes on someone's Facebook Wall, the message is generally addressed to the Wall owner alone (addressee), though anyone who can view that profile (being a side participant or bystander) is among the audience. Widespread practices with the Wall include long exchanges of messages that might apparently transpire in a similar way via email. This is a point to note two things. First, this difference between the addressee and audience found with the Wall is not new: guest books (both physical and digital), for example, have long supported this practice. Furthermore, in face-to-face communication, this distinction remains central and critical to speakers' and listeners' abilities to act appropriately. Consider this example, which illustrates how common-place this difference is:

> Alan must play close attention to these distinctions [between addressees, other participants, bystanders, and eavesdroppers] in saying what he says. [...] When he asks Barbara about his dog and Connie is in the conversation, he must make sure they see that it is Barbara, and not Connie, who is to answer his question. Yet he must make sure

> Connie understands what he is asking Barbara. He must also take account of overhearers [...]. He might, for example, try to conceal for [an overhearer] what he is asking Barbara by saying "Did you happen to see you-know-what [Alan's dog] come by here?" (Clark, 1996, p. 15)

Alan of course might also take extra effort to ensure that the overhearers understand him by making explicit even that which he would leave implicit if only speaking for the participants. This example also brings us to the second point. That is, a difference between addressee and audience makes a critical difference for communication: those long Wall exchanges would transpire differently, including having different real-world consequences for events and relationships, if they occurred via email, instant or text messaging, or phone.

For the purpose of charting the design space, we use the following values for ***audience***:

- **Private** indicates that the message has an audience of one. Examples of this include an SMS addressed to an individual.

- **Group** indicates that the message has an audience who's membership is completely controlled by the sender. An example of a message with a group audience is an email with a "to:" list (the recipients / participants) and a "cc:" list (participants / bystanders explicitly added by the sender). A slightly larger example of this would be posting an item to your Facebook profile where the group audience is your list of friends (recipients / participants / bystanders explicitly added by you).

- **Semi-public** indicates that the message has an audience that is not entirely controlled by the sender, but is still restricted. An example of a message with a semi-public audience is a Facebook wall post on someone else's wall. In this case the audience controlled by the owner of the wall, since their list of friends (as opposed to the sender's list of friends) can read the wall. In this case, the sender has some sense of constraints on the audience, but may not be acquainted with, fully aware of, or in control of the audience.

- **Public** indicates that the message has an unrestricted audience. Examples of messages with a public audience include a blog post on a public website.

It should be noted, that the actual audience for a message's content can dramatically change based on what the recipient does with the message (e.g., forward it to a reporter). However, for our purposes, we choose to ignore this aspect and focus on the immediate audience.

Similarly, we developed a taxonomy to classify the ***addressee***:

- **Individual** indicates that the message is addressed to one person as a recipient in the communication. For example, while a Facebook Wall post has a semi-public audience, it is addressed to an individual.

- **Multicast** indicates that the message is addressed to more than one person as a recipient, such as a list of people, or an interest group.

- **Broadcast** indicates that the message has no explicit addressee, and the sender is attempting to addressing a general audience. For example, a personal

website is an example of a communication for which the addressee is classified as broadcast.

See Figure 2 for a graphical overview of the interplay of addressee and audience in existing forms of communication. The figure also incorporates modality of the communication to further differentiate the resulting clusters of communication techniques. A quick scan of the figure brings to light that there are no forms of voice communication with an individual addressee and a group audience. After some brainstorming about this gap, we conceptualized a system that analyzes the social networks of phone call participants, and notifies mutual friends that the conversation is ongoing and gives them the opportunity to join in.

These dimensions are closely related to privacy and self-disclosure issues in CMC. A feature common to many SNS and other forms of CMC is the ability to specify a privacy policy for particular messages and other media objects. In posting a photo on Flickr, the poster can specify who can view it. That is, to some extent, they specify the audience, though who exactly is likely to or will view the photo can be hard to anticipate. For example, a search for a term used in an annotation of the photo might bring an otherwise unexpected, actual audience to the photo.

Given all the issues raised already, it should be clear that using a single dimension to capture the significant aspects of the audience in communication will require simplification and a degree of classification by fiat as cases that are in some ways dissimilar are collapsed into the same value for the dimension. On the other hand, a fuller set of dimensions would be more cumbersome when using

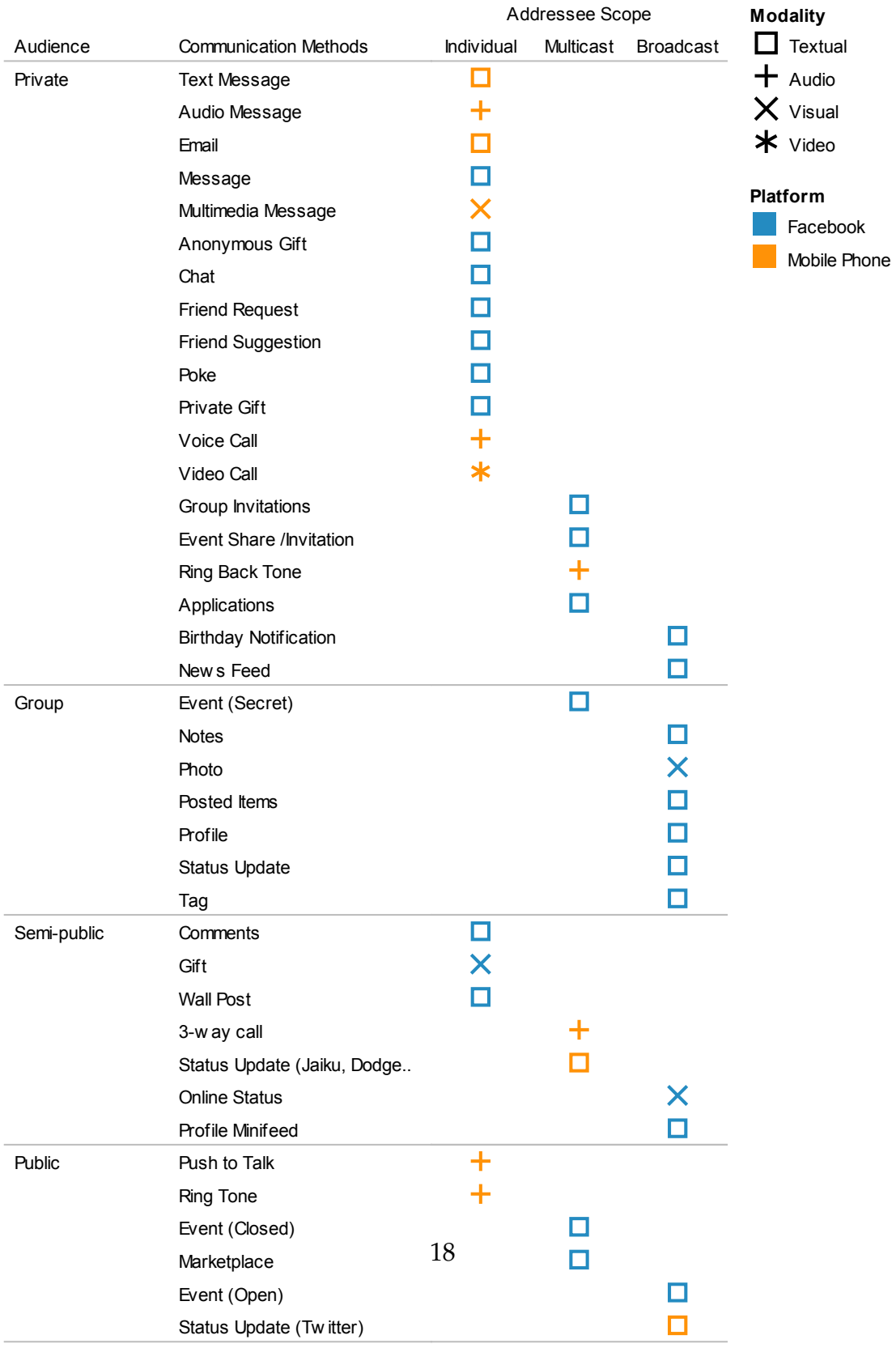

Figure 2: Addressee vs. audience of communication

the design space to, e.g., generate new ideas. We have chosen to both examine the underlying complexity, but also make the editorial decisions needed to present a single dimension. Consider the following questions, each focused on a different sense of "audience":

- Who is the actual audience? That is, who will actually be recipient of the communication (perhaps in some specified period, or for all time)?
- Who is the potential audience? That is, for some relevant notion of possibility, who *can* receive the communication?
- Who is the audience available for consideration? That is, what audience is available for consideration by the communicator?

A single audience dimension must therefore either focus on one of these senses at the exclusion of others, or merge them in some way. Specific instances must then be grouped or ordered as values for such a dimension. We assert that a critical family of considerations center around the communicator's control and knowledge of the audience. Two shared photos may have the exact same actual or even potential audience but nonetheless be critically different because of the communicator's knowledge and control. This is because psychological questions about audience involve not just the audience considered extensionally (the set of picked out by their beliefs), but the audience considered as the communicator considers it or as represented in feedback to the sender. The problems generated in these cases return in section 4.

Related to these questions of self-disclosure in CMC, there is one particular

kind of disclosure that is especially important in communication – that of the personal identity of the participants. The possibility for anonymity and pseudonymity in CMC has featured prominently in popular responses to the Internet, both as an opportunity (Barlow 1996) and a fear. Both of these concerns are suggested in the cartoon-derived adage "On the internet, nobody knows you're a dog" (Steiner 1993). We now introduce two dimensions, source and audience identity, that track these observations.

The ***source identity*** dimension distinguishes forms of communication in which the source is anonymous, the source is known through a pseudonym, and the real-world identity of the source is known. On this dimension, the starting points for communication on the Internet and mobile phones are very different: while the former has made accessible many means of anonymous and pseudonymous communication, mobile phone users, as used in the West, are associated with a fixed number that can be used to link them to all of their mobile communications. Interestingly communication on Facebook is nonetheless much more generally tied to real-world identities than other communication on the Internet, including other SNS, such as Friendster (Boyd and Heer 2006) and MySpace. Source identity is, however, more tightly enforced elsewhere, such as through Amazon's "real name" badge for reviewers, which requires name confirmation by credit card.

The complement of source identity is ***audience identity***. The additional of this dimension somewhat addresses the questions about the mechanisms for gaining knowledge about the audience: it represents mechanisms for knowledge of both

the potential and actual audience.[3] As an illustration of this dimension, consider the availability of mechanisms for learning about the actual audience of a SNS profile or shared photo. Users of Facebook are not provided any information about who views their profile. At the other extreme, users of Orkut and Friendster are able to see the list of the most recent viewers of a profile. LinkedIn, a SNS for professional contacts, by default allows users to see descriptions of their profile viewers such as "someone in the product management function at Microsoft"; the particular description chosen for a person is designed to always maintain some uncertainty about their exact identity. Systems that provide information about the number, region, and referring site or query of visitors – such as Flickr, YouTube, and Web analytics software – can also be described using this dimension.

3.3 Other dimensions

In constructing the proposed design space, we have taken up or adapted dimensions and descriptions proposed in previous work, but we have also not formally added many others that might nonetheless be valuable for understanding and design. And for the purpose of this paper, we have not included all the dimension that we have selected. Others we have included in a more complete version of this analysis include: semantic content (cf. Shannon and Weaver, 1949), compositionality (Frege 1914; Davidson 1967), record, extemporaneity, self-determination, and self-expression (Clark and Brennan 1991; Clark 1996).

[3]Though an interesting case, we exclude (currently rare) prospective mechanisms that predict who is likely to be part of the actual or potential audience. These are considered again in section 4

4 Active Mediation: Transformation, Synthesis, and Influence in Forms of Communication

Designers of interactive technologies design not only the system, but the behavior of its users and others. The Coordinator was a system designed to apply speech act theory to communication in business organizations: it required that those communicating through it explicitly specify the illocutionary force of their communications. Following its use and critical reception, Winograd (1986, p. 203) comments that:

> [W]hen we introduce a computer-based system, we are not just designing its structure and function, but are participating in the larger design of the organization and collection of practices in which it plays a role. We are designing (or re-designing) the work, not just the tool.

Like many artifacts and systems, interactive technologies can change attitudes and behaviors by design, but many features, including scalability, multi-modality, and ubiquity, give them flexibility and broad impact.

In this section, we consider forms of communication in which an information and communication technology system takes an active role in shaping, mediating, and synthesizing communication. We begin by reviewing two threads of research on active mediation and influence in CMC — persuasive technology (Fogg 2002) and transformed social interaction (Bailenson et al. 2004) — and relating them to each other and historical examples of active mediation. We then introduce some general categories of transformation and use these to guide a proposal of how to

represent active mediation in our dimensional analysis.

4.1 Persuasive technology

Interactive technologies are flexible in that they assume multiple roles: they can function as tools, simulations and games, and social actors. And in each of these roles they can change attitudes and behaviors through applying a variety of influence strategies (Fogg 2002). Like the present work, the study of persuasive technology has been simultaneously situated within the tradition of experimental social psychology research and explicitly oriented towards using case studies and organizing frameworks to generate new designs (Fogg 1998). Fogg (2002) uses taxonomies of functional roles (above) and of influence strategies to support generating designs for design problems formulated in terms of behavior and attitude change goals.

While HCI and individual behavior change is generally the focus of the study of persuasive technology, this approach can also be applied to the study and design of CMC (Oinas-Kukkonen and Harjumaa 2008). As a tool, a system can restructure the process of communication to "tunnel" the people into additional communication behaviors (e.g., adding a tag line to an event invitation), or a system can provide and make easy new behaviors through suggestion and reduction of effort (e.g., point-and-click selection of emoticons). As a social actor, a system can influence communication as a human mediator would, using social influence strategies to guide the participants' to a chosen goal. For example, a system can use praise and flattery to increase the perceived credibility of its advice regarding

an ongoing negotiation (Fogg and Nass 1997; Mishra 2006). A system could even use its own speech to speed up linguistic convergence among human participants in the conversation (Pearson et al. 2006).

Interactive technologies often assume multiple roles at once, or they persuade in ways that mix these roles. For example, in a case that straddles the boundary between a tool and a simulation, a SNS could provide a (potentially biased) calculation of the size and composition of the expected audience for a photograph that a user is about to share as a way of persuading users to vary their privacy settings for individual photos (Ahern et al. 2007).

While work on persuasive technology can generate forms of communication that feature active mediation, these function by changing relatively peripheral parts of the communication — changes which then influence the participants' communications through psychological processes. While less direct than the active mediation characteristic of the approach in the next section, this should still be understood as a change in the form of communication. For example, four people have a conversation face-to-face while each wearing headsets. A system gives feedback about how much each is taking on a display visible to all four (DiMicco et al. 2004). Alternatively, each participant receives private, personalized feedback on how much they are interrupting others and their personal goals for the conversation (Kass 2007). In both of these cases, it is clear that the setting has been substantially altered.

4.2 Transformed social interaction

CMC allows for the representation of communication behavior to be decoupled from the behavior itself, and the representation produced can be selected strategically (Bailenson et al. 2004). In operating on behavior, this allows for continuous, dynamic transformation; unlike decoupling represented source identity from actual source identity, more rapid, flexible, context- and goal-dependent change is generally possible.[4]

A central example of transformed social interaction is transformation of gaze. In particular, transformed social interaction makes non-zero-sum gaze possible: a participant's representation (e.g., an avatar in immersive virtual reality) can be looking in two directions simultaneously — at two other participants — because the two other participants can each see different representations (Bailenson and Beall 2006). This non-zero-sum gaze example combines two features that can apply in transformed social interaction: the representated behavior need not match the original behavior and the behaviors represented to different participants need not be consistent. Other transformations may only manifest the first. For example, an avatar can have its posture and gestures determined by the movement of another participant in order to mimic them in conversation, but the participant whose avatar is represented as mimicing for the other pariticpant could also see the mimicry represented.

Active mediation by information and communication technologies in ways

[4]For some exceptions to this contrast, in which identity is strategically manipulated differently over time and for different people, see (Bailenson et al. 2008).

consistent with both persuasive technology and transformed social interaction has long been a part of antipatory visions of the computer's role in communication. Two influentially figures in the creation and funding of modern computer science and the Internet, (Licklider and Taylor 1968) argued that the computer would be a new communication device, and not simply in the sense of routing information and switching channels. They saw face-to-face presentations mediated by shared simluations of proposed projects, computers running communication interference — filtering, aggregating, encouraging, and discouraging communicators, and computers transforming the central content of intimate social interactions for strategic effect — redrawing and embellishing a heart drawn for a loved one.

4.3 Kinds of transformation

To better understand the function of active mediation in communication settings, this work aims to characterize the types of transformations that mediated communication systems perform. Some such transformations include aggregating information (i.e., providing summaries of information streams), filtering information (i.e., providing a limited set of information streams), and modifying information (i.e., fundamentally transforming the nature of the information). Transformed social interaction is largely representative of modifying information. As future work for this communication design space exercise, we look toward more fully exploring the taxonomy of active mediation transformations that communication technologies employ in order to understand how future communication settings

will influence human communication.

4.4 Analysis and Representation of Transformation and Synthesis in the Medium

As described in section 2, we have aimed to select dimensions that match the individuation of our units of analysis. This is complicated by forms of communication that have multiple values for a dimension because of transformation, synthesis, or influence as part of the form of communication. Actively mediated forms of communication are not only the topic of design-oriented research, but they are already all around us. Sometimes this is accomplished through human mediators (e.g., translators in the United Nations, the many mediating roles in mass media production), but it can be made possible computationally. We see this manifest in the examples discussed immediately above, but also in widely practiced forms of communication in SNS, some of which have already made the classifications of section 3 difficult.

In aiming to subject actively mediated communication to morphological analysis, we need to either modify our dimensions so that these forms of communication assume only a single value or modify the unit of analysis so that forms of communication are composed of multiple points in the multidimensional design space.

After some consideration of what meaningful ordinal dimensions could work for the former, we have focused on exploring the latter approach. This requires introducing relations by which these points can be composed.

In doing so, we have been inspired by Card et. al.'s (1991) use of composition operators to represent the relationship between different input devices. On this kind of analysis, we can see complex input devices as having a (hyper)graph structure, where nodes are simple input devices (or complex input devices that are themselves graphs) and edges are the composition operators. For example, a mouse "is a layout composition of four devices: one device which is itself the merge composition of two elementary devices sensing change in X and Y and three other devices that are simple buttons" (Card et. al., 1990, p. 120). An additional composition operator of particular relevance is "connect" composition, in which the output of one device is mapped to the input of another, such as the mapping of a mouse output to the input for a cursor, a virtual input device (Card et. al., 1991, p. 104). This composition is a jumping-off point for our analysis.

We propose treating forms of communication settings as composed of multiple nodes. In particular, we propose composition by three nodes. The first has the basic morphology for the form of communication, and it can be thought of informally as the input node. The other two nodes have the morphology feedback to the communicator and representation to the recipients of the communication. The nodes can differ in value for any of the dimensions, but in the case where they do not, this is just a reinterpretation of the cases in which we have selected a single value for each dimension. Rather than thinking of the nodes for a form of communication as each having a different type, it is the relationships among them that are typed in this way. These relationships are directed edges, or arcs connecting the nodes: there is one arc type for output to recipients and one arc

type for output to feedback (Figure 3).

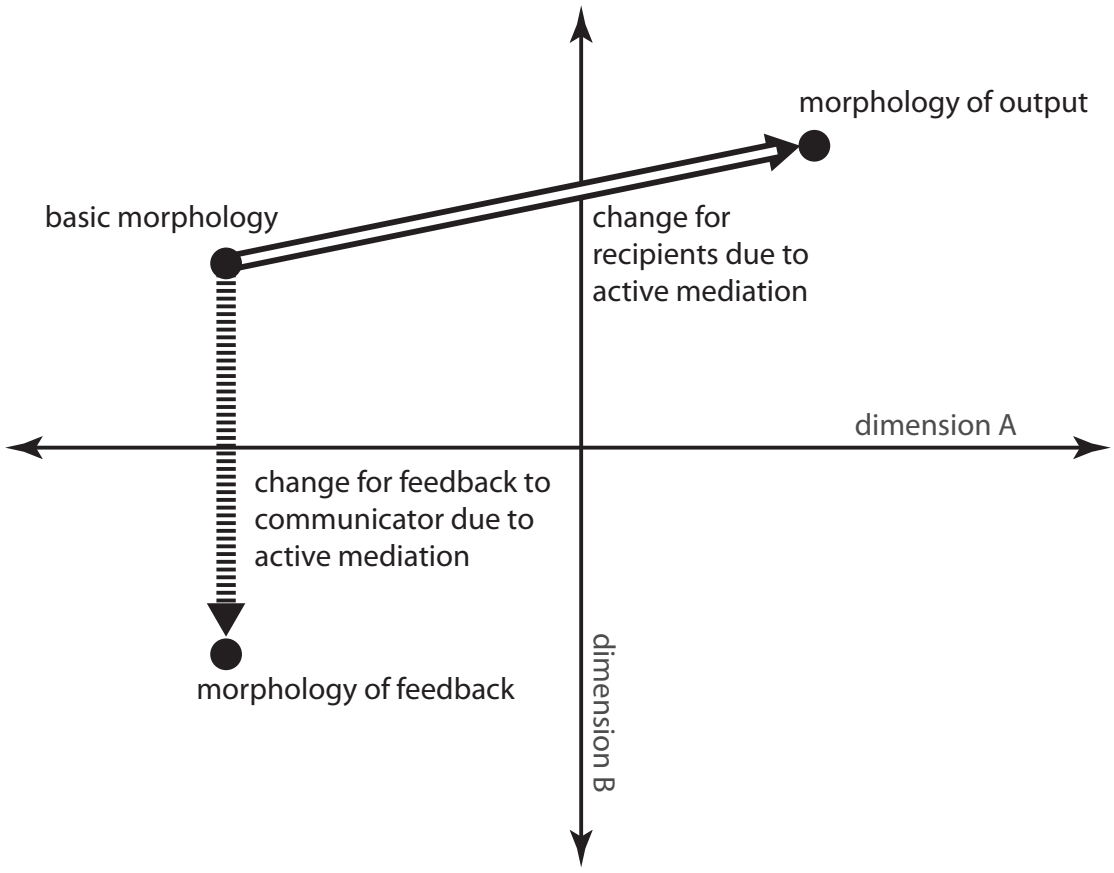

Figure 3: A form of communication involving active mediation is charted on two unspecified dimensions. The nodes are connected by two different types of arcs: an arc representing the change for feedback to the communicator, A_F; and an arc representing the change for recipients, A_R.

Let us consider a basic analysis in which we chart the nodes for a form of communication on a single dimension and there is active mediation only for the output to recipients. The arc is either increasing or decreasing for this dimension. In Figure 4, both of these cases are charted for a dimension that is the amount

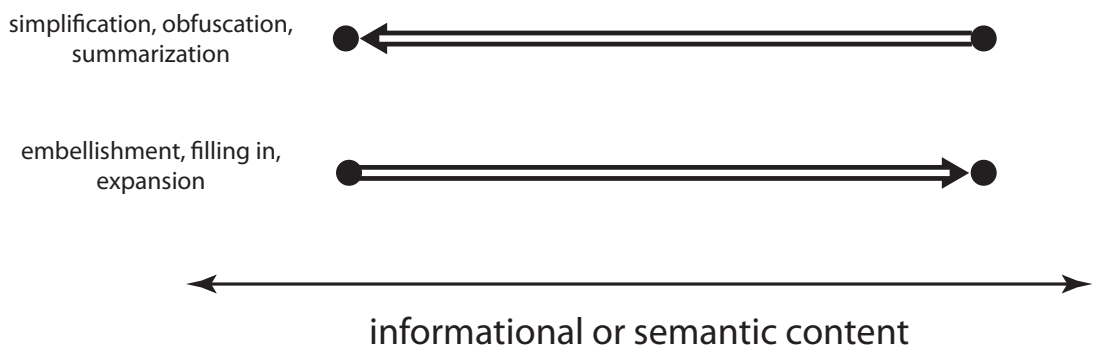

Figure 4: Two forms of communication involving active mediation are charted on a single dimension. In this case, the dimension is the amount of informational or semantic content. The nodes within each form of communication are connected by arcs for the change due to active mediation from the input to the recipients' representation. In the upper case, the information is decreased for presentation to the recipients. In the lower case, the information is increased for the recipients.

of informational content. In an application that includes functionality for sharing location information, one case in which the recipient arc would decrease for this dimension is when the detail of the location information in decreased from that specified by the communicator — whether this active mediation is carried out for the sake of privacy or ease of interpretation. Figure 3 charts on two dimensions a form of communication where there is active mediation for both arcs.

We have only sketched the basics of this means of subjecting actively mediated communication to morphological analysis. As this is ongoing work, we recognize that many questions remain about how well this approach will handle a variety of forms of communication and how it can best be used generatively.

5 Conclusion

In this first iteration of a communication design space, we have presented several important dimensions of forms of communication settings from existing literatures in psychology, psycholinguistics, communication, and computer science. As this design space gains more dimensions and forms of communication, we aim to provide a more systematic understanding of the use of communication technologies and a generative framework from which to consider new designs. We see analysis of active mediation as a challenge and important next step for this work; we have sketched a direction by which this kind of transformation, synthesis, and influence in the medium can be analyzed and represented.

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