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Abstract

Drawing on a specific scenario from a contemporary workplace, I review some of the dominant ways that management scholars have addressed technology over the past five decades. I will demonstrate that while materiality is an integral aspect of organizational activity, it has either been ignored by management research, or investigated through an ontology of separateness that cannot account for the multiple and dynamic ways in which the social and the material are constitutively entangled in everyday life. I will end by pointing to some possible alternative perspectives that may have the potential to help management scholars take seriously the distributed and complex sociomaterial configurations that form and perform contemporary organizations.

Nicole enters the Project Wonderland team room and sees Jon editing a design document on a large screen at the front of the room. She walks over to him and watches him work. After a while she asks some questions and then offers a number of suggestions for how he might improve the design he is working on. A few minutes later, Nigel walks out of his office and wanders into the team room, joining Nicole and Jon in front of the screen. He greets them both and Jon asks him for feedback on the design he and Nicole have been discussing. The three then engage in a lengthy conversation about the relative merits of different aspects of the design. At one point during the discussion, Nigel illustrates a particular idea he is proposing by making edits directly on the screen to the document that Jon is working on.

Some hours later, members of the Project Wonderland team start assembling for their weekly meeting. Jon walks into the conference room, sits down, and begins an informal conversation about music with a few of the other team members who have already arrived. Nicole and Nigel walk towards the conference room, pausing at the entrance to finish their lively discussion of some recent TV ads aired by opposing political campaigns. After all but one of the members has arrived, they take their seats at the conference table. The ninth member is currently driving to a client site and so she calls into the meeting on her cell phone. Once everyone is settled, the meeting begins.

A normal day at the office for a software development team? Not quite. I have omitted an important detail. The Project Wonderland rooms, offices, screens, and documents are part of an online, three-dimensional, immersive environment for workplace collaboration within Sun Microsystems, known as MPK20.[1] Within this graphically intensive virtual workplace, users interact in real time using audio, text, and images, and they share applications and content from a variety of online sources.[2] Jon, Nicole, and Nigel's presence in, navigation of, and interaction with the Project Wonderland space (including other team members) is provided by personalized on-screen graphical representations known as avatars (see Figure 1), which are manipulated through such devices as mice, keyboards, microphones, and speakers. While their avatars are "co-located" within MPK20, the Project Wonderland team members are geographically distributed across the United States. Today, for example, Nicole is in her office in the Burlington, Massachusetts location of Sun Microsystems, Jon is sitting in the company cafeteria on Sun's campus in Menlo Park, California, and Nigel is working out of his home in Seattle, Washington.

Scenarios such as this one are not yet common in workplaces around the world. However,

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[1] The main campus of Sun Microsystems at Menlo Park, California has 19 buildings, numbered MPK1 to MPK19. The next (virtual) building was thus numbered MPK20 [http://research.sun.com/projects/mc/mpk20.html]

[2] Project Wonderland is built on an open source software infrastructure developed by Sun Microsystems and comprising client and server components. The server component includes *Darkstar,* a platform designed for scalable, multi-user online games and virtual worlds, and *jVoiceBridge* for handling high-fidelity audio mixing and telephonic integration. Both interoperate via multiple networks with the client software running on individual team members' computers.

they are likely to grow in importance as "synthetic worlds" — the term generally used to describe environments such as MPK20 (Castronova, 2005; Malady, 2006) — are developed and taken up in various contexts. In the consumer sector, participation in synthetic worlds such as Second Life and World of Warcraft is estimated in the tens of millions (Hof, 2006; Nardi and Harris, 2006), while synthetic worlds are also emerging as interesting sites of experimentation among scientists, educators, and software teams (Bainbridge, 2007; Hut, 2008; Moore and Jackson, 2008; Schultze et al., 2008). In organizations, a number of dedicated synthetic worlds — such as Project Wonderland (from Sun Microsystems), ProtoSphere (from ProtonMedia), Olive (from Forterra Systems), and Qwaq (from Qwaq) — are being deployed within organizations for the purposes of supporting distributed collaboration, project management, and online learning and simulation.[3]

The use of synthetic worlds for organizational activities such as distributed collaboration raises interesting questions for scholars — how to make sense of and study these in management research? What are some existing perspectives that might usefully be drawn on to do so, what new or alternative perspectives might be more relevant, and what are the implications of choosing certain perspectives over others in accounting for and articulating particular issues and insights?

In what follows, I will draw on the scenario sketched above to explore the different ways that the management literature has addressed and accounted for technology over the years. This consideration will necessarily be both partial and broad: partial, because I examine only the main perspectives that have been developed over this period; and broad, because I will focus on general characterizations of a wide range of studies conducted with different intentions, theories, and methodologies. My interest here is not to offer a detailed review of various organizational accounts of technology,[4] but to highlight distinctive positions and suggest some contrasts, problematics, and opportunities. More specifically, I suggest that pursuing alternative perspectives on, and ontologies of, technology may be especially important and valuable for making sense of the sorts of virtual and distributed phenomena such as MPK20 that are likely to become a more significant part of contemporary organizational realities.

Established Perspectives on Technology in Management Research

Three distinctive conceptual positions on technology are clearly evident in the management literature of the past few decades. In the first perspective, which I will characterize as *absent presence*, technology is essentially unacknowledged by organizational researchers, and thus unaccounted for in their studies.[5] In the second perspective, technology is posited to be an *exogenous force* — a powerful driver of history having determinate impacts on organizational life. The third perspective, that of *emergent*

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[3] A number of trade conferences have sprung up around the use of such synthetic worlds, including http://www.3dtlcdc.com/ and http://virtualworldsforum.com/

[4] For detailed reviews of the research on technology in management studies, see Barley (1988), Dewett & Jones (2001), Orlikowski & Scott (2008), Roberts & Grabowski (1996), and Zammuto et al. (2007).

[5] Gergen (2002) introduces the idea of "absent presence" by describing a group of people sitting in a room together, engrossed in their own thoughts and activities, and not acknowledging each other's presence.

process, technology is positioned as a product of ongoing human interpretations and interactions, and thus as contextually and historically contingent. Recently, a fourth perspective on technology — that of *entanglement in practice* — has attracted interest within management research, largely influenced by longer-standing developments in sociology and science and technology studies (Latour, 2005; Suchman, 2007). As I will describe below, this alternative perspective entails a commitment to a relational ontology that undercuts the dualism that has characterized but also limited much of the prior technology research in management studies. In particular, this perspective offers the potential to radically reconceptualize our notions of technology and reconfigure our understandings of contemporary organizational life.

Absent Presence

In 1992, Latour observed that artifacts were missing in action from most sociological accounts of everyday life. He could as easily have been commenting on the management literature and its accounts of organizational life. Despite an early interest in manufacturing technology (e.g., Woodward, 1958; Harvey, 1968; Hickson, Pugh, and Pheysey, 1969), organizational scholars have mostly ignored the materiality of everyday organizing. Indeed, a number of assessments of management research over the years have found that considerations of technology are largely absent from the core logics of organizational theorizing. For example, Pinch and Bijker (1987, p. 21) observe "... in the economic analysis of technological innovation everything is included that might be expected to influence innovation, except any discussion of the technology itself." In their review of information systems research, Orlikowski and Iacono (2001, p. 130) note, "In the majority of articles over the past decade, artifacts are either absent, black-boxed, abstracted from social life, or reduced to surrogate measures." And more recently, Zammuto et al. (2007, p. 750) find that only 2.8 percent of the research articles published over the past decade in four leading organizational journals in the USA have focused on technology and organizations.[6]

We are thus faced with the apparent contradiction that while technology is everywhere to be found in organizational life, it is largely absent from the recent management literature. To borrow an observation from Barad (2003), it seems that matter does not matter very much in most studies of organizational reality. A common explanation for this absence of materiality in the management literature is that technology is either invisible or irrelevant to researchers trained in social, political, economic, and institutional analyses of organizations. For these researchers, ontological priority is given to human actors and social structures, and as a result, technological artifacts (and materiality more generally) tend to disappear into the background and become taken for granted. With such a perspective, it is not surprising that scholars do not work on questions about artifacts, and research done on this view thus underestimates the role and significance of technological artifacts. The specific case of an environment such as the MPK20 synthetic world described in the scenario is unlikely to be salient to such management scholars, and they would be less inclined to give it attention in their studies of organizational life.

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[6] The four journals included in the survey were *Academy of Management Journal, Academy of Management Review, Administrative Science Quarterly,* and *Organization Science.*

Still, the potential scale and perceived control associated with synthetic worlds might prompt a few management researchers to conduct some social experiments with them. For example, Bainbridge (2006, p. 473) notes that synthetic worlds "provide environments and tools that facilitate creating online laboratories that can automatically recruit potentially thousands of research subjects, over a period of months, at low cost." He further suggests:

> Creative scientists may also be able to design experiments that are feasible in virtual worlds but were never possible before. For example, experiments can be done comparing the socioeconomic consequences of alternative government regulations, something next to impossible in society at large.

Following this suggestion, organizational researchers could use synthetic worlds methodologically, as platforms for coordinating and conducting their inquiries into social behavior. They are unlikely, however, to inquire into the specific technological entailments of synthetic worlds, how they are taken up and changed by participants, or how they configure participants' interactions and with what outcomes. In the absent presence perspective thus, the role and influence of synthetic worlds for distributed collaboration — like technology more generally — will likely remain backstage concerns.

Exogenous Force

The second conceptual understanding of technology in management studies assumes that technology is an exogenous and relatively autonomous driver of organizational change, and as such, that it has significant and predictable impacts on various human and organizational outcomes, such as governance structures, work routines, information flows, decision making, individual productivity, and firm performance (e.g., Blau et al., 1976; Pfeffer and Leblebichi 1977; Carter, 1984; Huber, 1990; Brynjolfsson and Hitt, 1998). This broad stream of management research developed in the late 1950s and 1960s with a number of studies of manufacturing technology and its relationship to forms of organizing (Woodward, 1958; Harvey, 1968; Hickson, Pugh, and Pheysey, 1969). In these studies, technology was seen primarily as "hardware" — discrete objects including equipment, machines, and instruments — posited as distinct and separate from humans and organizations, and hypothesized to directly impact human behaviour and organizational characteristics.

Most scholars adopting an exogenous force perspective have followed the prescripts of a variance logic (Mohr, 1982), seeking to theorize the relationship between technology and organization sufficiently generally, so that predictions about technology effects may be made across types of organizations and technologies. This framing of technology as a material and causal determinant of organizational elements served as a key aspect of the influential stream of management research known as "contingency theory" (Klein, 2006). Spanning the sixties and seventies, this stream of work generated considerable empirical research into the range of contingencies believed to influence technological impacts on organizations (Perrow, 1986). While acknowledgement of various contingencies has served to check excessive claims of technological determinism, a strong commitment to the powerful effects of technology on people and organizations has continued to inform this research tradition.

Following the early focus on industrial technology — where technology was defined in terms of types of manufacturing hardware — subsequent research began to include technologies of varying forms and purposes (Perrow, 1967; Glisson, 1978). Indeed, the notion of technology became decidedly abstract over time, being described in terms of the characteristics of tasks (e.g., complexity or predictability) that were seen to be proxies for technology. For example, Blau et al.'s (1976) definition of technology, intended to include machines in both the factory and the office, was specified as "the substitution of equipment for human labor" (1976, p. 21). In another example, Fry and Slocum (1984) investigated the impact of technology on organizational structure and workgroup effectiveness by assessing technology in terms of three constructs: (1) the degree of unfamiliarity in the job (measured as the number of exceptions encountered by workgroup members in performing their tasks); (2) the scale of search activities undertaken by workgroup members to resolve the encountered exceptions; and (3) the extent of interdependence required by workgroup members to accomplish their tasks. These kinds of expansion of the definition of technology allowed for greater research generalizability, but they did not affect the posited relationship of technology to organizations. That is, scholars proceeded to conceptualize technology as a material determinant of organizational characteristics, while paying limited attention to either specific technological details or the role of human agency in shaping technology.

Later research continued to define technology largely in terms of various proxy measures. For instance, economic studies focused on the productivity impacts of information technology by measuring technology through financial metrics such as the specific amounts of money spent by firms or industries on computer systems (e.g., Brynjolfsson and Hitt, 1998; Melville, Kraemer and Gurbaxani, 2004; Aral and Weill, 2007). In another example, media richness theory (Daft and Lengel, 1984, 1986; Trevino, Webster and Stein, 2000) attempted to explain the impacts of communication media by assessing a medium's "capacity to convey information that may reduce uncertainty and equivocality" via such measures as: (1) opportunity for timely feedback, (2) capability to convey multiple cues, (3) means to tailor messages to personal circumstances, and (4) language variety (Huber and Daft, 1987, p. 152). Subsequent work by Huber (1990) focused on "advanced information technology" which he defined as rationality-enhancing devices that transmit, manipulate, analyze, or exploit digital information, and which have made their appearance since 1970. He posited that these devices facilitate easier, cheaper, and more controlled communication and information transfer, and predicted that they will enhance the quality of organizational intelligence and reduce the number of hierarchical levels involved in decision-making.

Proponents of the exogenous force view have tended towards a positivist approach in their research, being interested in deriving generalizable laws from statistical empirical work. As such, they have been more inclined to look across instances rather than at individual cases of technology use. Such scholars would generally not be interested in studying the specific instance of the MPK20 synthetic world. Instead, common features of various synthetic worlds would be assessed (or represented through proxies such as investment value or information richness) in an attempt to produce statistical regularities

about the effects of synthetic worlds in general. These worlds would be predicted to produce certain identifiable impacts on organizations, including impacts on the phenomenon of distributed collaboration. For example, studies might focus on how investments by organizations in synthetic worlds influence the productivity of distributed participants, and how these effects might vary across such type of team, organization, or industry. These studies might also investigate how the uses of various media available within synthetic worlds (e.g., audio, text, video, file sharing, etc.) might be associated with more or less effective communication among the distributed participants. These relationships would likely be posited as being moderated by a number of contingencies including size (e.g., of participating team, community, etc.), demographics (e.g., younger vs. older workers), status (e.g., managers, experts, etc.), task (e.g., routine, novel, etc.), and structure (e.g., hierarchical vs. networked organizational forms).

Emergent Process

Challenging the notion that technology is an autonomous, external force, scholars adopting an emergent process perspective argued that technology results from the ongoing interaction of human choices, actions, social histories, and institutional contexts. Technology is here understood as material artifacts that are socially defined and socially produced, and thus as relevant only in relation to the people engaging with them. Ontological priority is given to the role of human agency in technological change, marking a shift away from abstract and exogenous understandings of technology to a view of technologies as fundamentally social, grounded in specific historical and cultural contexts, and dependent on specific meanings and contingent processes. A methodological shift is also entailed in this perspective, as researchers draw on a process logic (Mohr, 1982), conducting and constructing detailed historical and ethnographic accounts of technological production, use, and change.

Central to an emergent process perspective is the notion that understandings of technology are neither fixed nor universal, but that they emerge from situated and reciprocal processes of interpreting and interacting with particular artifacts over time. Thus, an emergent process perspective focuses primarily on the embedded and dynamic meanings, interests, and activities that are seen to produce an ensemble of technological relations (Kling, 1991; Markus and Robey, 1988). Scholars working from this perspective sought to explain how the particular interests and situated actions of multiple social groups shaped the designs, meanings, and uses of new technologies over time (Ciborra and Lanzara, 1994; Fulk, 1993; Heath and Luff, 2000; Prasad, 1993; Thomas, 1994; Zuboff, 1988). For example, Kling and his colleagues developed what they termed a "web model of computing," focusing on the broader ecology of people, infrastructures, resources, policy decisions, and social relations that affected the development, adoption, appropriation, and adaptation of information technology (Gasser, 1986; Kling and Dutton, 1982; Kling and Iacono 1984; Kling and Scaachi, 1982).

The emergent process perspective in management studies has been influenced by a number of different streams of thought. An early influence was the research conducted by the socio-technical systems school (Trist and Bamforth, 1951), which argued that social, psychological, environmental and technological systems must be assessed as a whole

(Griffith and Dougherty, 2001). They challenged the technocentric focus of traditional work design, promoting the idea that social and technical elements in a system mutually shape each other and thus must be jointly designed (Mumford, 1981; Davis and Taylor, 1986). Another strong influence on the emergent process perspective came from science and technology scholars' interest in the social shaping (MacKenzie and Wajcman, 1985) and social construction of technology (Bijker, Hughes and Pinch, 1987; Bijker and Law, 1992; Woolgar and Grint, 1991). By insisting that the "black-box" of technology must be opened, these scholars effectively unpacked the socio-historical processes through which technologies were shaped by the multiple and often competing interests, interpretations, and identities of salient social groups.

A third influence on the emergent process perspective in management studies has been Giddens' (1984) structuration theory. While this theory does not explicitly consider technology, its focus on processes of social structuring has informed analysis of the structuring of technologies within organizations (Jones and Karsten, 2008; Roberts and Grabowski, 1996). For example, Barley (1986) studied the implementation of CT scanning technology in two separate hospitals, finding that different groups of users — radiologists and technicians — engaged differently with "the same technology," occasioning distinct structuring dynamics and contrasting shifts in power relations. Subsequent studies have examined how computer technologies are shaped during the processes of construction and use (e.g., DeSanctis and Poole, 1994; Jones 1998; Orlikowski, 1992; Walsham, 1993), articulating notions of structural appropriation (DeSanctis and Poole, 1994), improvised learning (Boudreau and Robey, 2005), and technologies-in-practice (Orlikowski, 2000) to understand the multiple ways in which work practices and social structures mediate and are mediated by engagement with the new technology.

With respect to studying the MPK20 synthetic world, researchers following an emergent process perspective would likely conduct detailed analyses of specific interpretations of and interactions in MPK20 to understand how such a world enables and constrains distributed collaboration. Thus, researchers might conduct ethnographic studies of the MPK20 environment, becoming members of Project Wonderland and participating in the various events and activities of the team. These inquiries might examine how members' communication in MPK20 differs from their face-to-face interaction, how the roles, norms, and identities generated by members within MPK20 resemble or differ from those outside of MPK20. Other studies might examine the production of the MPK20 synthetic world, investigating the historical origins of such worlds, and the interpretations and actions of the designers and engineers who constructed MPK20 — what were their intentions, interests, and values in producing this synthetic world, how did they imagine the users and their activities within the world, what tools and techniques did they use to generate the code, how did their inscriptions in the MPK20 code depart from their espoused aspirations and assumptions, and so on. Structurational accounts might focus on what forms of structuring are evident in users' situated engagements with MPK20, comparing the practices of Project Wonderland team members within and outside of MPK20 in an attempt to identify whether and how existing or new structures for

distributed collaboration are enacted by team members in the synthetic world, and with what individual, team, and organizational consequences over time.

Problems with Established Perspectives on Technology in Management Research

While the two perspectives of exogenous force and emergent process have generated valuable insights into the role of technology in organizations, they have also received their share of criticisms. A number of specific weaknesses have been identified that limit the potential for these perspectives to address some of the novel technological phenomena — such as the MPK20 synthetic world — that are becoming more common in contemporary organizations. Other examples of such emerging phenomena include social media, virtual design, assistive robots, digital mobility, and various forms of distributed and algorithmic agencies that perform the online transactions operating global financial markets, supply chains, and internet commerce. The two established research perspectives on technology in organizations are arguably not well equipped to address such contemporary phenomena, in part due to some of the difficulties outlined below.

Research that views technology as an exogenous force has been criticized for ignoring or downplaying the role of history, social context, and human agency in shaping technology production, use, and change. Not surprisingly, given the ontological priority of this perspective, the answers obtained by studies in this tradition privilege the technology, while the social and historical aspects of technology design, construction, and use are overlooked, abstracted, or assumed away (Orlikowski and Iacono, 2001). By reifying technology, the perspective is rendered unable to theorize or explain the role of human agency and socio-historical practices in technology relations.

This exogenous force perspective has also been criticized for disregarding or reducing the dynamic and situated materialities that constitute technologies, and for tending to assume unproblematically that technology is largely exogenous, autonomous, homogeneous, predictable, and stable, and that it will operate as intended and designed across time and place (Orlikowski, 2007). These assumptions are not borne out in practice, as Orlikowski and Iacono (2001, p. 131) note:

> Artifacts are usually made up of a multiplicity of often fragile and fragmentary components, whose interconnections are often partial and provisional and which require bridging, integration, and articulation in order for them to work together. We have a tendency to talk of [technological] artifacts as if they were of a piece—whole, uniform, and unified. For example, we talk about "the Technology," "the Internet," "the Digital Economy," as if these are single, seamless, stable, and the same, every time and everywhere. While such simplifications make it easy to talk about technologies, they also make it difficult to see that such technologies are rarely fully integrated, flawless, and unfailing, and that they can and often do break down, wear down, and shut down.

Researchers adopting an exogenous force perspective are inclined to follow a variance logic in their studies, and thus tend to be interested in developing operationalizations of technology that will afford comparability, generalizability, and predictability. Accordingly, the more abstract the conceptualizations of technology and organization they use, the more prepared they are to advance general explanations and predictions beyond the specific technologies and contexts that they have studied. What gets lost in this trade-off, however, is the capability to posit and theorize about the context-specificity

of technological artifacts and the subtle, situated, and micro-level practices of technology construction and interaction that produce particular organizational outcomes. For example, as Orlikowski and Iacono (2001, p. 132) continue:

> Differences in system configurations, infrastructures, bandwidth, interfaces, accessibility, standards, training, business models, and citizens' rights and responsibilities guarantee that the experience of, say, "being on the Internet" in China will be different from that in Saudi Arabia or in the United States, let alone in various microcontexts of use.

Research that views technology as an emergent process has also been subject to critique. While this perspective situates the production and use of technology in particular socio-cultural and historical contexts, it has been criticized for minimizing the role of technology, and specifically sidelining the physical characteristics and capabilities entailed in particular technological objects (Faulkner and Runde, 2009). An emergent process perspective avoids reifying technology, but it also tends to downplay specific technological properties and affordances, focusing primarily on human interpretations and social actions. Given the ontological priority of this perspective, it is not surprising that the answers obtained by studies in this tradition privilege situated human agency. The consequence of this emphasis on the social, however, as Button (1993) and Berg (1997) have contended, is that the technological side of the relationship disappears from view. The human-centric focus of the emergent process perspective inhibits assigning agential power to the distinctive technological capabilities that interact with human interpretations and social action. What is lost in this trade-off, thus, is the capability to posit and theorize the material effects of technological artifacts.

The emergent process perspective has also been challenged on a number of additional points. For example, questions have been raised about some of the studies that assume that technological artifacts stabilize during design ("reach closure"). Critics have argued that such a presumption privileges the design stage and overlooks the ongoing and open-ended process of reinterpretation and reworking through which technological artefacts are modified and updated during use over time (Wajcman, 2000; Woolgar and Cooper, 1997). As Wajcman (2002, p. 353) notes: "Technological change is a thoroughly contingent and heterogeneous process. … Thus users can radically alter the meanings and deployment of technologies." In another challenge, Winner (1993) has argued that by focusing essentially on grounded and contingent interpretations and interactions of technology (whether during design and/our use), the emergent process perspective neglects the wider political and societal consequences of technology. This difficulty is related to a more general critique made of this perspective — that in being primarily concerned with the specifics of situated micro-interactions, it is unable to offer widely-applicable insights into the ways in which technologies broadly shape organizations and societies.

Towards Alternative Perspectives on Technology in Management Research

While the first perspective on technology in management research — absent presence — overlooks the relevance of technology in organizational life, the other two perspectives — exogenous force and emergent process —appear to make quite different assumptions about the nature, role, and influence of technology in organizations. In particular, there is a critical difference in the ontological priority given — on the one hand, to the *technology* and the often accompanying search for invariant technological impacts across time —

and on the other hand, to the *social* and the often accompanying exploration of multiple, emergent and situated human-technology interactions over time. Despite these apparent differences, a closer examination indicates that the two perspectives share an underlying core presumption — that technology and humans are essentially different and separate realities. In this respect, both perspectives are based on an *ontology of separateness,* that is, "an ontology of separate things that need to be joined together" (Suchman, 2007, p. 257). These perspectives similarly share "a simple dualistic view of agency which claims that agency is located either in the human or in the artefact" (Introna, 2007, p. 3).

While an ontology of separateness has long influenced the social sciences— a legacy of Cartesian dualism — its primacy has been challenged in recent decades, particularly through developments in science and technology studies (Barad, 2003). Scholars here have been working within a *relational ontology,* which rejects the notion that the world is composed of individuals and objects with separately attributable properties that "exist in and of themselves" (Law, 2004, p. 42). Such an ontology privileges neither humans nor technologies (Knorr Cetina, 1997; Pickering, 1995; Barad, 2003; Latour, 2005; Schatzki, 2002), nor does it treat them as separate and distinct realities. As Introna (2009, p. 26) writes:

> It would not be incorrect to say that our existence has now become so entangled with the things surrounding us (if it even makes sense to use the notion of 'surround') that it is no longer possible to say, in any definitive way, where we end and they begin, and vice versa. […] We are the beings that we are through our entanglements with things – we are thoroughly hybrid beings, cyborgs through and through.

Thus, the social and the technical are posited to be "ontologically inseparable from the start" (Introna, 2007, p.1), and as Suchman (2007, p. 257) notes, "the starting place comprises configurations of always already interrelated, reiterated sociomaterial practices." On this view, capacities for action are seen to be enacted in practice, and the focus is on constitutive entanglements (e.g., configurations, networks, associations, mangles, assemblages, etc.) of humans and technologies. Such a relational ontology informs a number of perspectives that are beginning to influence research on technology in the management literature, and which may be characterized with the label "entanglement in practice."

Entanglement in Practice

One influential example of an entanglement perspective is that of Actor Network Theory (ANT), originally developed by sociologists Michel Callon (1986) and Bruno Latour (1987), and used by a number of organization scholars to examine sociotechnical relations in the workplace (Berg, 1997; Kaghan and Bowker, 2001; Monteiro and Hanseth, 1996; Scott and Wagner 2003; Walsham and Sahay, 1999). ANT proposes that entities have no inherent qualities, but acquire their form and attributes only through their relations with others in practice. From this perspective, there are no distinct and separate social or technological elements that might shape, or be shaped by, each other. Rather, technological artifacts should be treated symmetrically to the humans, and as equivalent participants in a network of humans and non-humans that (temporarily) align to achieve particular effects. ANT entails a specific methodology for studying the "co-evolution of sociotechnical contexts and sociotechnical content" (Law and Callon, 1994, p. 21),

whereby actors (human and non-human) assemble and associate the interests of others in a common project.

Other scholars working within a relational ontology have proposed additional conceptualizations, such as the notion of sociomateriality which focuses on how meanings and materialities are enacted together in everyday practices (Barad, 2007; Introna, 2007; Suchman, 2007). In developing an account of sociomateriality, Barad (2003) draws on Niels Bohr's metaphysics to challenge the tendency towards what she terms "thingification" where relations are turned into "things," "entities," or "relata" with determinate boundaries, properties, and meanings. As she writes (2003, p. 802):

> [D]uring the nineteenth century, Nietzsche warned against the mistaken tendency to take grammar too seriously: allowing linguistic structure to shape or determine our understanding of the world, believing that the subject and predicate structure of language reflects a prior ontological reality of substance and attribute. The belief that grammatical categories reflect the underlying structure of the world is a continuing seductive habit of mind worth questioning.

In response, Barad (2003) argues for a performative metaphysics that shifts the focus away from "independent objects with inherent boundaries and properties" to *practices,* matters of doings/actions that perform particular phenomena. Phenomena, on this account, are "ontologically primitive relations—relations without preexisting relata" that are enacted in material-discursive practices (Barad, 2003, p. 815). From such a performative perspective, technologies have no inherent properties, boundaries, or meanings, but are bound up with the specific material-discursive practices that constitute certain phenomena. In contrast to the "Cartesian cut" that enacts a determinate ontology with inherent distinctions and boundaries, Barad (2003) argues for ongoing and dynamic "agential cuts" that perform and stabilize/destabilize particular distinctions, boundaries, and properties within phenomena in practice. Such material-discursive practices thus enact specific local resolutions to ontological questions of the nature of phenomena.

Barad (2003) develops the notion of *apparatus* to refer to the specific material-discursive practices that help to constitute phenomena through producing knowledge about them. Following Bohr's rationale for the inseparability of "observed object" and "agencies of observation," she argues that the boundaries and properties of phenomena are not ontologically prior, but become determinate only in relation to the specificity of the observing apparatus. That is, given particular methods of observing, measuring, or examining a phenomenon, certain properties of that phenomenon will become determinate, while others will be specifically excluded (Barad, 2007, p. 20). On this view, apparatuses are boundary-making practices that focus agencies of observation on one thing instead of another. Rather than regarding empirical findings as a mirror or lens through which we can see reality, findings are read *through* the apparatus (Scott and Orlikowski, 2009).

With respect to our synthetic world scenario, a perspective of entanglement would focus on understanding MPK20, not as the necessary result of a powerful technological infrastructure, or as principally reflecting the interpretations and interactions of the human developers or users, but as a dynamic sociomaterial configuration performed in practice. Rather than attributing agency either to individual actors (designers, engineers,

team members) or particular technologies (computers, algorithms, graphics engines, networks), capacities for action would be studied as relational, distributed, and enacted through particular instantiations of the MPK20 synthetic world. Drawing, for example, on the notion of apparatus, researchers might study how different performances of the MPK20 synthetic world configure communication and information sharing in Project Wonderland, and how these make some practices and knowledge more salient and determinate than others, and with what consequences. A sociomaterial perspective would highlight how synthetic worlds are not neutral or determinate platforms through which distributed collaboration is facilitated or constrained, but integrally and materially part of constituting that phenomenon. Researchers might also examine how integrating MPK20 into everyday practices reconfigures the phenomenon of distributed collaboration within an organization, and what implications this generates for inclusion and exclusion, for responsibility and control. Researchers would also question how their agencies of engaging with the MPK20 synthetic world enacts certain boundaries around the phenomenon, in part constituting it as a particular object of study with particular entailments for their resulting accounts and attendant accountabilities.

Conclusion

The scenario of synthetic worlds I began with provided the occasion to examine some distinctive aspects of established and emerging perspectives on technology evident in the management literature. These perspectives provide different purchase on the phenomenon of synthetic worlds in particular, and technology in general. As discussed, for the majority of management scholars, materiality is not salient or integral enough in organizational life to warrant consideration. Confronted with synthetic worlds, these researchers will in all probability focus their attention elsewhere. And this choice has consequences for the value of organizational scholarship: "to the extent that the management literature continues to overlook the ways in which organizing is critically bound up with material forms and spaces, our understanding of organizational life will remain limited at best, and misleading at worst" (Orlikowski and Scott, 2008, p. 466).

Other management scholars will attempt to understand synthetic worlds as an exogenous force affecting various aspects of organizational life. They will characterize these worlds and their impacts using a range of abstract measures that will attempt to identify relationships, tendencies, and effects that extend broadly and hold generally across technologies and contexts. As this perspective presumes technologies to be largely given, homogeneous, and stable artifacts that perform as designed across time and place, these investigations will miss the multiple, contingent, and unpredictable ways in which human engagement shapes synthetic worlds and interactions within them over time (Steinkuehler, 2006; Taylor, 2006).

Still another group of management scholars will focus on generating grounded and textured insights into how meanings and interactions shape, and are shaped by, people's navigation of and engagement with synthetic worlds, and how such emergent processes produce various forms of organizing. Given their relative inattention to technological entailments, however, these studies will be unable to articulate the various ways in which different technological capabilities within the synthetic worlds will have particular effects

in the world and on the participants, nor will they be able to explain how the situated materiality of specific synthetic worlds affords particular modes of interacting (Zammuto et al., 2007).

A fourth set of management scholars will argue that privileging either the technologies or the humans reduces human agency on the one hand, and technological performances on the other, to relatively passive and reactive roles. They will argue that presuming that technology is a relatively fixed set of capabilities that are seamless, stable, and the same, everywhere, and most of the time, obscures the multiple, messy, complex, and dynamic aspects of technologies at work (de Laet and Mol, 2000). Similarly, they will say that focusing on the "impacts" or "uses" of technology masks "the constitutive intertwining and reciprocal interdefinition of human and material agency" (Pickering, 1995, p. 26). Indeed, they will suggest that all practices (including research practices) are always configured by some specific sociomateriality, and thus to study synthetic worlds, we must study the dynamic and multiple sociomaterial (re)configurations as these are performed in practice. They will conclude, as I do here, by suggesting that the perspective of entanglement may be particularly useful for management research going forward. As contemporary forms of technology and organizing are increasingly understood to be multiple, fluid, temporary, interconnected, and dispersed (Child and McGrath, 2001; Ciborra, 1996; Law and Urry, 2001; Stark, 1999), a perspective that renounces the categorical presumption of separateness is likely to offer a more useful conceptual lens with which to think about the temporally emergent sociomaterial realities that form and perform contemporary organizations.

References

Aral, S. and Weill, P. 2007. "IT Assets, Organizational Capabilities and Firm Performance," *Organization Science,* 18, 5: 763-780.

Bainbridge, W.S. 2007. "The Scientific Research Potential of Virtual Worlds," *Science,* 317, 5837: 472 – 476.

Barad, K. 2003. Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter," *Signs,* 28, 3: 801-831.

Barad, K. 2007. *Meeting the University Halfway: Quantum Physics and the Entanglement of Matter and Meaning.* Durham, NC: Duke University Press.

Barley, S.R. 1986. "Technology As an Occasion for Structuring: Evidence From Observations of CT Scanners and the Social Order of Radiology Departments." *Administrative Science Quarterly* 31:78-108.

Barley, S.R. 1988. "Technology, Power, and The Social Organization of Work," *Research in the Sociology of Organizations*, 6: 33-80.

Berg, M. 1997. "Of Forms, Containers, and the Electronic Medical Record: Some Tools for a Sociology of the Formal," *Science, Technology, & Human Values,* 22, 4: 403-433.

Bijker, W.E., Hughes T.P. and Pinch, T. (eds.) 1987. *The Social Construction of Technological Systems.* Cambridge MA: MIT Press

Bijker, W.E. and Law, J. (eds.) 1992. *Shaping Technology*, *Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press.

Blau, P.M., Falbe, C.M., McKinley, W. and Tracy, P.K. 1976. "Technology and Organization in Manufacturing," *Administrative Science Quarterly*, 21: 20-40.

Boudreau, M.-C. and Robey, D. 2005. "Enacting Integrated Information Technology: A Human Agency Perspective." *Organization Science*, 16, 1: 3-18.

Brynjolfsson, E. and Hitt, L. 1996. "Paradox Lost? Firm-level Evidence on the Returns to Information Systems Spending." *Management Science,* 42, 4: 541-558.

Button, G. 1993. "The Curious Case of the Vanishing Technology," in Button, G. (ed.) *Technology in Working Order: Studies in Work, Interaction, and Technology.* London: Routledge: 10-28.

Callon, M. 1986. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of Saint Brieuc Bay." In J. Law (ed.) *Power, Action and Belief: A New Sociology of Knowledge?* London: Routledge, 196-233.

Carter, N.M. 1984. “Computerization as a Predominate Technology: Its Influence on the Structure of Newspaper Organizations,” *Academy of Management Journal,* 27, 247-270.

Castronova, E. 2005. *Synthetic Worlds: The Business and Culture of Online Games,* University of Chicago Press: Chicago, IL.

Child, J., R.G. McGrath. 2001. Organizations Unfettered: Organizational Form in an Information-Intensive Economy,” *Academy of Management Journal,* 44, 6: 1135-1148.

Ciborra, C.U. 1996. The Platform Organization: Recombining Strategies, Structures, and Surprises. *Organization Science,* 7, 2: 103-118.

Ciborra, C. and Lanzara, G.F. 1994. ‘Formative Contexts and ICT: Understanding the Dynamics of Innovation in Organizations’. *Accounting, Management and Information Technology*, 4, 2: 61-86.

Daft, R. L. and Lengel, R.H. 1986. “Organizational Information Requirements, Media Richness and Structural Design,” *Management Science,* 32, 5: 554-571.

Dalai Lama 2005. *The Universe in a Single Atom.* New York: Broadway Books.

Davis, L.E. and Taylor, J.C. 1986. “Technology, Organization and Job Structure.” In R. Dubin, (ed.), *Handbook of Work, Organization, and Society*, Chicago IL: Rand McNally, 379-419.

de Laet, M. and Mol, A. 2000. “The Zimbabwe Bush Pump: Mechanics of a Fluid Technology,” *Social Studies of Science*, 30, 2: 225-263.

DeSanctis, G. and Poole, M.S. 1994. “Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory,” *Organization Science,* 5, 2: 121-147.

Dewett, T. and Jones, G.R. 2001. “The Role of Information Technology in the Organization: A Review, Model, and Assessment,” *Journal of Management,* 27, 3: 313-346.

Faulkner, P. and Runde, J. 2009. “On the Identity of Technological Objects and User Innovations in Function,” *Academy of Management Review,* 34, 3: 442-462.

Fulk, Janet. 1993. “Social Construction of Communication Technology.” *Academy of Management Journal* 36: 921-50.

Gergen, K.J. 2002. “The Challenge of Absent Presence.” In J.E. Katz and M. Aakhus (eds.), *Perpetual Contact*. Cambridge, UK: Cambridge University Press, 227-241.

Giddens, A. 1984. *The Constitution of Society: Outline of the Theory of Structure.* Berkeley CA: University of California Press.

Glisson, C.A. 1978. "Dependence of Technological Routinization on Structural Variables in Human Service Organizations." *Administrative Science Quarterly* 23: 383-95.

Griffith, T.L. and Dougherty, D.J. 2001. "Beyond Socio-Technical Systems," *Journal of Engineering and Technology Management*, 18, 1-12;

Harvey, E. 1968. "Technology and the Structure of Organizations." *American Sociological Review*, 33, 2: 247-259.

Heath, C. and Luff, P. 2000. *Technology in Action.* Cambridge, UK: Cambridge University Press.

Hickson, D.J., Pugh, D.S. and Pheysey, D.C. 1969. "Operations Technology, and Organization Structure: An Empirical Appraisal," *Administrative Science Quarterly,* 14: 378-397.

Hof, R.D. 2006. "My Virtual Life," *BusinessWeek,* May 1, 2006.

Huber, G.P. 1990. "A Theory of the Effects of Advanced Information Technologies on Organizational Design, Intelligence, and Decision Making," *Academy of Management Review,* 15, 1: 47-71.

Huber, G.P. and Daft, R.L. 1987. "The Information Environments of Organizations." In F. Jablin, L. Putnam, K. Roberts and L. Porter (eds.), *Handbook of Organization Communication.* Beverly Hills, CA: Sage.

Hut, P. 2008. "Virtual Laboratories and Virtual Worlds." In E. Vesperini, M. Giersz and A. Sills (eds.) *Proceedings of the IAU Symposium No, 246: Dynamical Evolution of Dense Stellar Systems*. International Astronomical Union: http://arxiv.org/pdf/0712.1655v1

Hutchby, I. 2001. "Technologies, Texts and Affordances," *Sociology,* 35, 2: 441-456.

Introna, L.D. 2007. "Towards a Post-human Intra-actional Account of Sociomaterial Agency (and Morality)." Paper prepared for the *Moral Agency and Technical Artefacts Workshop,* The Hague: Netherlands Institute for Advanced Study.

Introna, L.D. 2009. "Ethics and the Speaking of Things," *Theory, Culture and Society,* 26, 4: 25–46.

Jones, M.R. 1998. "Information Systems and the Double Mangle: Steering a Course between the Scylla of Embedded Structure and the Charybdis of Material Agency." In Larsen, T., Levine, L. and DeGross, J.I. (eds.) *Information Systems: Current*

Issues and Future Challenges. Laxenburg: International Federation for Information Processing, 287-302.

Jones, M.R. and Karsten, H. 2008. "Giddens's Structuration Theory and Information Systems Research," *MIS Quarterly,* 32, 1: 127-157.

Jones, M.R. and Orlikowski, W.J. 2007. "Information Technology and the Dynamics of Organisational Change." In R. Mansell, C. Avgerou, D. Quah and R. Silverstone (eds.) *The Oxford Handbook on Information and Communication Technologies.* Oxford, UK: Oxford University Press, 293-313.

Kaghan, W.N. and Bowker, G.C. 2001. "Out of Machine Age?: Complexity, Sociotechnical Systems and Actor Network Theory," *Journal of Engineering and Technology Management,* 18, 3: 253-269.

Klein, L. 2006. "Applied Social Science: Is it just Common Sense?" *Human Relations,* 59, 8: 1155–1172.

Kling, R. 1991. "Computerization and Social Transformations," *Science, Technology, & Human Values*, 16, 3: 342-367.

Knorr Cetina, K. 1997. "Sociality with Objects: Social Relations in Postsocial Knowledge Societies," *Theory, Culture & Society,* 14, 4: 1–30.

Latour, B. 1987. *Science in Action.* Cambridge, MA: Harvard University Press.

Latour, B. 1992. "Where are the Missing Masses? Sociology of a Few Mundane Artefacts." In W. Bijker and J. Law (eds.) *Shaping Technology, Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press: 225-258.

Latour, B. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory.* Oxford, UK: Oxford University Press.

Law, J. 2004. *After Method: Mess in Social Science Research.* New York: Routledge.

Law, J. and Urry, J. 2004. "Enacting the Social," *Economy and Society*, 33, 3: 390-410.

Fry, L.W. and Slocum, J.W. Jr. 1984. "Technology, Structure, and Workgroup Effectiveness: A Test of a Contingency Model," *Academy of Management Journal*, 27, 2: 221-246.

MacKenzie, D. and Wajcman, J. (eds.) 1985. *The Social Shaping of Technology.* Milton Keynes, UK: Open University Press.

Malady, T. 2006. "Parlaying Value: Capital in and Beyond Virtual Worlds," *Games and Culture*, 1, 2: 141-162.

Markus, M.L. and Robey, D. 1988. "Information Technology and Organizational Change: Causal Structure in Theory and Research," *Management Science*, 34, 5: 583-598.

Melville, N., Kraemer, K.L. and Gurbaxani, V. 2004. "Information Technology and Organizational Performance: An Integrative Model of IT Business Value," *MIS Quarterly,* 28, 2: 283-322.

Mohr, L.B. 1982. *Explaining Organizational Behavior.* San Francisco, CA: Jossey-Bass.

Monteiro, E. and Hanseth, O. 1996. "Social Shaping of Information Infrastructure: On Being Specific about the Technology." In W.J. Orlikowski, G. Walsham, M.R. Jones and J.J. DeGross (eds), *Information Technology and Changes in Organisational Work*, London: Chapman & Hall, 325-343.

Moore, E. and Jackson, P. 2008. "Getting Real Work Done in Virtual Worlds." Cambridge MA: Forrester Report: http://www.forrester.com/Research/Document/Excerpt/0,7211,43450,00.html

Mumford, E. 1981. "Participative Systems Design: Structure and Method," *Systems, Objectives, Solutions*, 1, 1: 5-19.

Nardi, B. and Harris, J. 2006. "Strangers and Friends: Collaborative Play in World of Warcraft," *Proceedings of 20th Conference on Computer-Supported Cooperative Work.* Banff, Canada: 149-158.

Orlikowski, W.J. 1992. "The Duality of Technology: Rethinking the Concept of Technology in Organizations," *Organization Science,* 3, 3: 398-427.

Orlikowski, W.J. 2000. "Using Technology and Constituting Structures." *Organization Science.* 11, 4: 404–428.

Orlikowski, W.J. 2007. "Sociomaterial Practices: Exploring Technology at Work," *Organization Studies*, 28: 1435-1448.

Orlikowski, W.J. and Iacono, C.S. 2001. "Desperately Seeking the "IT" in IT Research—A Call to Theorizing the IT Artifact." *Information Systems Research*, 12, 2: 121-134.

Orlikowski, W.J. and Scott, S.V. 2008. "Sociomateriality: Challenging the Separation of Technology, Work and Organization," *Annals of the Academy of Management*, 2, 1: 433-474.

Perrow, C. 1967. "Framework for the Comparative Analysis of Organizations," *American Sociological Review,* 32: 194-208.

Perrow, C. 1986. *Complex Organizations: A Critical Essay.* New York: Random House.

Pfeffer, J. and Leblebici, H. 1977. "Information Technology and Organizational Structure, *Pacific Sociological Review*, 20, 2: 241-261.

Pickering, A. 1995. *The Mangle of Practice: Time, Agency and Science.* Chicago, IL: The University of Chicago Press.

Pinch, T.J. and Bijker, W.E. 1984. "The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," *Social Studies of Science*, 14, 3: 399-441.

Prasad, P. 1993. "Symbolic Processes in the Implementation of Technological Change: A Symbolic Interactionist Study of Work Computerization," *Academy of Management Journal*, 36: 1400-1429.

Roberts, K., and Grabowski, M. 1996. "Organizations, Technology and Structuring." In S. Clegg & C. Hardy & W. Nord (eds.), *Handbook of Organization Studies*. London: Sage Publications: 409-423.

Schatzki, T.R. 2002. *The Site of the Social: A Philosophical Account of the Constitution of Social Life and Change.* University Park, PA: Pennsylvania State University Press.

Schultze, U., Rennecker, J., Hiltz, R., Nardi, B. and Stucky, S. 2008. "Synthetic Worlds in Work and Learning," *Communications of the AIS*, 22, 19: 351-370.

Scott, S.V. and Orlikowski, W.J. 2009. "'Getting the Truth': Exploring the Material Grounds of Institutional Dynamics in Social Media," Paper presented at the *25th European Group for Organizational Studies Conference,* Barcelona, Spain.

Scott, S.V. and Wagner, E.L. 2003. "Networks, Negotiations, and New Times: The Implementation of Enterprise Resource Planning into an Academic Administration," *Information and Organization*, 13, 4: 285-313.

Stark, D. 1999. "Heterarchy: Distributed Authority and Organizing Diversity." In J.H. Clippinger, (ed.) *The Biology of Business: Decoding the Natural Laws of Enterprise.* San Francisco, CA: Jossey-Bass, 153-179.

Steinkuehler, C. 2006. "The Mangle of Play," *Games and Culture,* 1, 3: 199-213.

Suchman, L.A. 2007. *Human-Machine Reconfigurations: Plans and Situated Actions.* Cambridge, UK: Cambridge University Press.

Taylor, T.L. 2006. "Beyond Management: Considering Participatory Design and Governance in Player Culture," *First Monday,* Special Issue #7: http://www.uic.edu/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/1611/1526

Thomas, R.J. 1994. *What Machines Can't Do: Politics and Technology in the Industrial Enterprise.* Berkeley, CA: University of California Press.

Trevino, L.K., Webster, J. and Stein, E.W. 2000. "Making Connections: Complementary Influences on Communication Media Choices, Attitudes, and Use," *Organization Science,* 11, 2: 163-182.

Trist, E.L. and Bamforth, K.W. 1951. "Some Social and Psychological Consequences of the Longwall Method of Coal-Getting," *Human Relation,* 4, 1: 3-38.

Wajcman, J. 2000. "Reflections on Gender and Technology Studies: In what State is the Art?" *Social Studies of Science,* 30, 3: 447–64.

Wajcman, J. 2002. "Addressing Technological Change: The Challenge to Social Theory," *Current Sociology,* 50: 347-363.

Walsham, G. 1993. *Interpreting Information Systems in Organizations.* Chichester, UK: Wiley.

Walsham, G. and Sahay, S. 1999. "GIS for District-level Administration in India: Problems and Opportunities." *MIS Quarterly,* 23, 1: 39-65.

Winner, L. 1993 "Upon opening the Black Box and Finding it Empty: Social Constructivism and the Philosophy of Technology," *Science, Technology and Human Values,* 18, 3: 362–378.

Woodward, J. 1958. *Management and Technology*. London: HMSO.

Woolgar, S. and Cooper, G. 1999. "Do Artefacts Have Ambivalence?: Moses' Bridges, Winner's Bridges and Other Urban Legends in S&TS," *Social Studies of Science,* 29: 433-449.

Woolgar, S. and Grint, K. 1991. "Computers and the Transformation of Social Analysis," *Science, Technology, & Human Values,* 16, 3: 368-378.

Zammuto, R.F., Griffith, T.L., Majchrzak, A., Dougherty, D.J. and Faraj, S. 2007. "Information Technology and the Changing Fabric of Organization," *Organization Science,* 18, 5: 749-762.

Zuboff, S. 1988. *In the Age of the Smart Machine.* New York: Basic Books.

Figure 1: Screen Shot of Project Wonderland in the MPK20 Environment