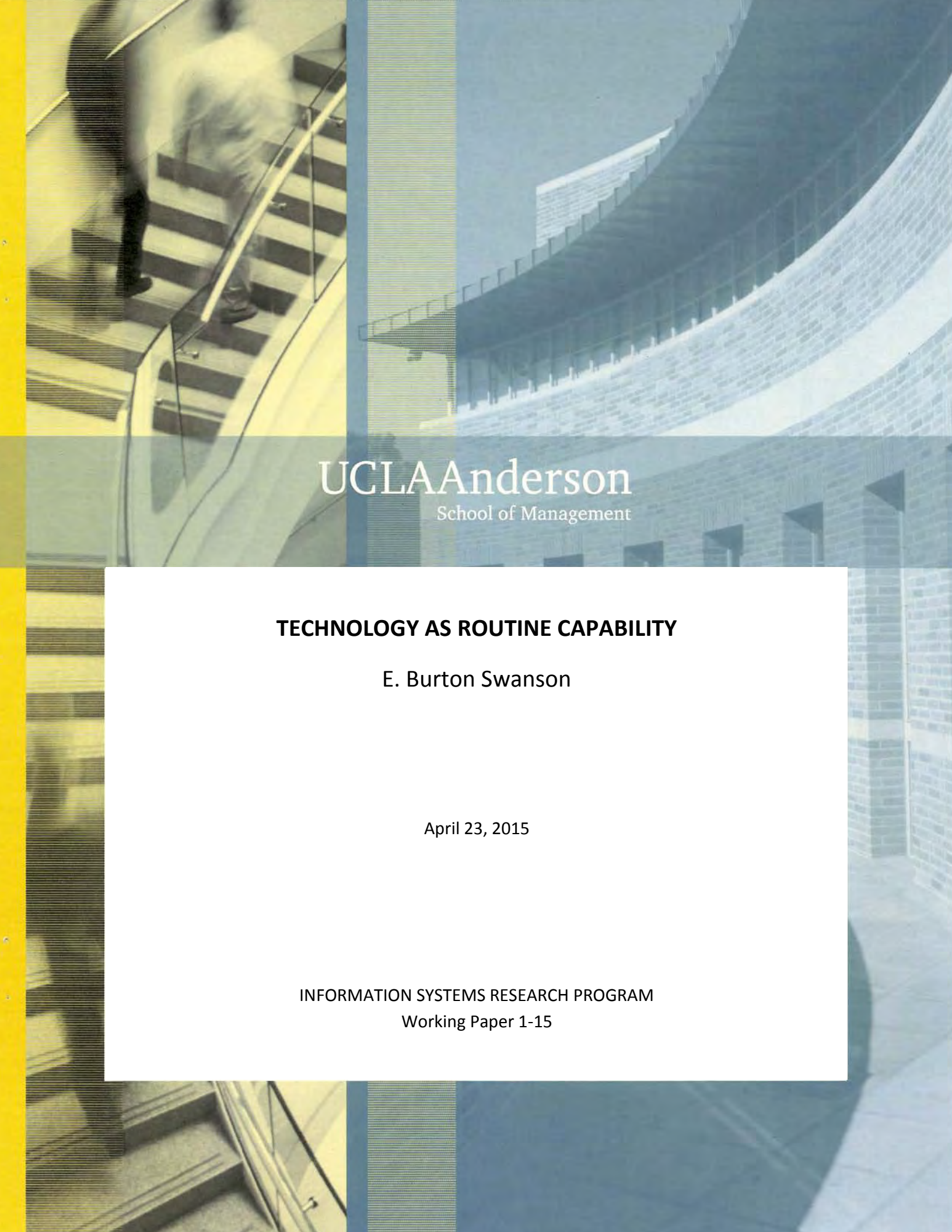

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Technology as Routine Capability

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April 23, 2015

Abstract

Technology is most commonly associated with material things, tools or artifacts. But technology is also theoretically associated with routines, patterns of action that provide capabilities. Schatzki's practice theory allows for an overarching perspective that ties tools as devices to routines in a broader social context and offers insights into technological change, in particular, in the information technology (IT) context.

Keywords: technology, artifacts, routines, practices, technological change, information systems

As a thought exercise, imagine a Paleolithic man, Brian, with no technology, not even a laptop. Hungry, Brian seeks repeatedly without success to pry open a walnut. Frustrated, he reaches for a nearby right-sized rock and crushes the nut. Turning a summersault in joy, Brian repeats the action, opening more walnuts with increasing skill. Voila! A new technology discovered in the early Stone Age. Question: which came first, the tool or the routine? Not that Brian would have paused to reflect on this!

In the present paper, we explore the relationship of tool to routine in the context of modern information technology (IT). We are motivated by the simple and now commonplace observation that our world is increasingly saturated with technologies, more digital than traditionally physical, many of great consequence (see Yoo, 2013). We seek to gain perspective and new understanding of how all this has come about since the Time of Brian.

We know that we're not alone in this and much has already been said, by technologists, sociologists, economists, historians, and philosophers (see, e.g., Bijker, Hughes, Pinch, and Douglas, 2012; Orlikowski, 2009). We won't attempt a review of this vast literature here. Rather, drawing selectively from it, our more modest aim is to bring routines to the foreground of the technology story, as we believe they deserve to occupy a more prominent position than they are commonly given.

Tools have thus far dominated, perhaps because many are physical, real to our eyes, and too because they provide a historical trace when rediscovered long after being abandoned. Thus, while technology is an umbrella term with a variety of usages, it is most commonly associated with stuff, i.e. material things, tools, or artifacts (Orlikowski and Iacono, 2001).

Arthur (2009) in an important recent treatise defines technology more broadly, as a "means to fulfill a human purpose", a "method or process or device" (p. 28). However, his theory of technology, while ambitious and encompassing, is developed largely around devices, i.e. material things, or tools. Swanson (2015) provides a brief review in the IT context.

Recent IT-related research, e.g., Leonardi (2011) and Pentland and Jung (2014), has described how technologies as devices are often intertwined with routines, patterns of action that typically employ them (Feldman and Pentland, 2008), our present focus. However, routines are presented as distinct from technology.

Closely related research taking a sociomaterial view (Orlikowski and Scott, 2008; Cecez-Kecmanovic, D., et al, 2014) focuses on technologies as assemblages of the material and the social in practice, but not necessarily on actions and routines as such. It does, however, concern itself with "capacities for action" (Orlikowski, 2009, p. 11), which will ultimately be aligned with our own viewpoint.

We argue that the prevailing view of technology as devices, as well as much research that blends the material with the social, has thus far masked the role of routines in technologies and their development. In particular, at the broadest level, the device perspective doesn't provide a satisfactory explanation of how a society comes to equip itself with its technologies, or even what it should mean for it to do so.

To illustrate the issue, consider, for instance, ERP (Enterprise Resource Planning) technology in businesses (see Klaus, Rosemann, and Gable, 2000). What should it mean to say that a particular industry possesses ERP technology? A device-centric view would presumably focus on the software and its acquisition across the industry. A routine-centric view, we suggest, would focus on the industry's *actual use* of the software in support of its business processes. The two views are by no means equivalent, as much research finds that the acquisition of ERP software has not translated easily among firms into improved routines and business processes (Davenport, 2000; Markus and Tannis, 2000; Scott and Vessey, 2002). What was promised by ERP as device was not what was necessarily delivered, pending substantial organizational learning, first implementing, then employing the software (Aral, Brynjolfsson, and Wu, 2006). Too, what was (and continues to be) learned with ERP differs from the original vision.

In short, we suggest that technology is as much if not more about what we are able to *do* with our devices, by means of our routines, than with the devices themselves. This suggestion of course is not wholly new. It has substantial roots in a great body of research, in particular in information systems (IS), focused on achieving favorable organizational outcomes. But this research over the years has not only often ignored devices; it has only recently begun to address the role of routines in change beyond the single organization, and it has spoken little to change in technology.

How, then, might the role of routines be better understood as part of the technology story? Here we develop an overarching perspective to address this question, building from the work of others. In what follows, we first consider *technology as device*, relying on Arthur (2009), and drawing from Swanson (2015). We then extend this view to what will be termed *technology as routine capability*. Schatzki's (2002) practice theory allows for the development of the overarching perspective. From this vantage point, we consider change in technology and what brings it about, and how it may be understood, first as change in devices, the prevailing view, then, to greater advantage, as change in routine capabilities.

Arthur's work

Brian Arthur's theory of technology, as presented in his book, is inspired by his quest to understand technology and its relationship to the economy, and more subtly, the ways in which economic development is intertwined with technology development. Arthur begins by

addressing basic questions, previewing where he will arrive, which is to explain technological development as a process of combinatorial evolution: “Early technologies form using primitive technologies as components. These new technologies in time become possible components-- building blocks-- for the construction of further new technologies. Some of these in turn go on to become possible building blocks for the creation of further new technologies. In this way, slowly over time, many technologies form from an initial few, and more complex ones form using simpler ones as components. The overall collection of technologies bootstraps itself upward from the few to the many and from the simple to the complex. We can say the technology creates itself out of itself.” (p. 21)

Arthur provides a broad definition of technology as “a means to fulfill a human purpose,” (p. 28), “a device, or method, or process,” (p. 29), which is subsequently refined to evoke more familiar notions of technology as that achieved by applying scientific understandings of physical phenomena. The theory he develops does not ultimately depend on how broadly or narrowly the definition is applied.

He asserts a set of “three fundamental principles” from which his theory will be developed: “The first will be … that technologies, all technologies, are combinations. This simply means that individual technologies are constructed or put together- combined- from components or assemblies or subsystems at hand. The second will be that each component of technology is itself in miniature a technology. … And the third… will be that all technologies harness and exploit some effect or phenomenon, usually several.” (p. 23)

The first two principles, asserting the combinatorial and recursive aspects of technology, are straightforward, while profound. The third principle, that all technologies harness and exploit some effect or phenomenon, is easily understood for technologies tied closely to nature and the physical world. Thus, for instance, “That certain objects—pendulums or quartz crystals—oscillate at a steady frequency is a phenomenon. Using this phenomenon for time keeping constitutes a principle, and yields from this a clock.” (p. 49). However, its application to very different engineered means, such as information systems, where the notion of what effect or phenomenon is being harnessed is more subtle, and is anchored in human behavior, is arguably more problematic (Swanson, 2015).

Arthur goes on in subsequent chapters to address and build upon these basic ideas. He discusses: technological domains; engineering practice; novel technologies and how they arise; technology development; redomaining; technology evolution; and the economy as an expression of the technologies employed. The ambitious character and scope of the work should be apparent.

In sum, while Arthur's theory allows for a broader interpretation, he builds it largely around technology as devices. Importantly, while the role of devices is well described, devices are characterized as in and of themselves *executable*. No distinction is drawn between devices and their means of execution in human settings, namely, routines. Rather, Arthur blends these concepts, suggesting that devices somehow "embody" a sequence of operations for executing their functionality (p. 31). We claim instead that most such operational sequences are generated in the broader execution of routines serving human practices. They are not the province of the devices alone. Indeed, the history of devices is one in which they evolve substantially in being repurposed by new routines that advance human practices. Routines lead (and call for) devices as much as devices lead (and call for) routines. We elaborate next.

Routines, capabilities, and human practices

Accordingly, to shed new light on the role of routines, building from Arthur's work, we introduce the complementary notion of technology as *routine capability*, by which we simply mean the capability associated with routines as such. Often, though not always, this entails the accomplishment of some task. That routines provide for such capabilities is well established in the literature, though often without much elaboration. (Most recently, researchers have debated whether "micro-foundations" for routines and capabilities are needed. The argument revolves around actors and agency, more than artifacts. See, e.g., Felin and Foss, 2011. Winter (2013) offers a critique.)

Too, the notion that technology offers capability is not really new. In the form of the production function, it is basic to neo-classical economic theory of the firm. However, this theory says nothing further as to the inner workings of technology. Nelson and Winter (1982), taking an evolutionary approach, first suggested that it is routines to which we should look.

Strategy research, addressing competitive advantage, has, however, come to focus on what is termed dynamic capabilities, an attribute of firms and their managements, more than on routine capabilities, associated with operations, interpreted as "ordinary" (see Teece, Pisano, and Shuen, 1997; Winter, 2003). And IS researchers have often followed this lead (see, e.g., Bharadwaj, 2000).

But if many routine capabilities provide no competitive advantage, they are no less socially or economically important simply because most firms share them. On the contrary, such rough parity may more or less define what it means for an industry to possess a technology. An industry advances when most its members bring themselves up to speed, not just when a single one innovates, pushing things ahead. Industry and professional associations are thus often very active in promoting new technologies seen to be important to all, as, for instance, with current

attention being given to "smart manufacturing." (See the website of the Smart Manufacturing Leadership Coalition.)

Following Pentland and Feldman (2008), routines are understood here as patterns of action, by people, but also machines. Having both ostensive and performative aspects, routines typically employ devices, some as actants (Latour, 2005). Indeed, we observe that many, if not most, devices are employed only through routines, even while others serve as embedded components. To the extent that many devices have capabilities or offer *affordances*, then, it is largely through the routines that employ them. Still, the notion that devices in and of themselves offer affordances persists. (See Norman (1990) and Gaver (1991) on the notion of affordances.)

Too, routines have their purposes. Broadly, a technology, as a routine capability, serves to advance a *human practice*. The concept of "human practice" is given a broad institutional interpretation here and is understood to entail a family of routines executed in coordination, and, to some extent, socially in common. An organizational example is university administration. Thus, universities may seek to apply IT to faculty hiring, and promotion and tenure routines currently mired in paperwork. (In fact, our own university is presently implementing a new system to achieve this capability.) Human practices also include those by individuals, e.g. consumers. A highly promoted example is holiday shopping in U.S. stores on Black Friday, and online on Cyber Monday. (Advancing a human practice may or may not be a noble endeavor.)

The notion of practice is a rich one in the literature, especially in social philosophy (see, e.g., Pickering, 1993; Schatzki, 2002, 2011; Feldman and Orlikowski, 2011). It has also been insightfully applied, for instance to management accounting (Ahrens and Chapman, 2007), as well as information systems (Jones and Karsten, 2008). Here, in the interest of advancing theory, we tie it explicitly to the notion of routines, while also differentiating it. In doing so, we rely specifically on Schatzki's (2002) deeply informed practice theory as presented in his book, *The Site of the Social*. Schatzki illustrates his "social ontology" in part by applying it to an IT-based practice close to our own interest, namely, day trading on the NASDAQ, to which we will make reference.

Schatzki observes that "social life is plied by a range of such practices as negotiation practices, political practices, cooking practices, banking practices, recreational practices, religious practices, and educational practices." (p. 70). He defines practice as "a bundle of activities, … an organized nexus of actions," themselves "a set of sayings and doings" manifested in tasks and projects (p.71). The notion of tasks, grounded in actions, tracks closely to that of routines and will be interpreted here as such.

When we speak of *advancing* a human practice, we will mean achieving a more favorable social position for it. This often entails improving upon its economics, social acceptance, or politics, simplifying it or otherwise reducing its costs, for instance, or finding new outlets for it, expanding its presence, or increasing its appeal, making it more enjoyable, or obtaining favored social treatment for it, or improving its reputation.

Those people and organizations engaged in a practice will understandably usually seek to advance it, often out of perceived necessity, and this provides ongoing motivation for improving upon its associated family of routines. Thus, U.S. retailers work hard to promote holiday shopping, as it accounts for much of their annual profit.

Institutionally interpreted, it is understood that a human practice takes place across social units, e.g. across universities. Some will be leaders in the adoption of a new technology, while others will be followers. (Our own university in its administrative initiative is following the lead of others. However, it is customizing the software to its own established routines, for example.) Leaders in adoption must typically work out many of the problems with a new technology on their own, or with a partner. Followers may benefit from the community that forms to promote the diffusion of the technology, in support of best practices, to the broader population.

An overarching perspective

Practice theory is further much concerned with social orders. How prevailing orders shape practices, enable or constrain them, and are often reinforced by them, is a common theme in the literature (classics include Bourdieu (1972) and Giddens (1984)). Schatzki offers instead the thesis that social practices are the contexture in which social orders are themselves constructed. (p.89) For Schatzki, practices are primary in bringing about *social worlds* that come to exist: "In sum, social orders are largely established in practices. The relations among, meanings of, and, hence, positions of, the components of social orders are beholden, above all, to the doings and sayings that compose practices, in conjunction with practice organizations. The arrangements of people, artifacts, organisms, and things that help form the site of the social are laid down primarily in the interweaving and inter-related nexuses of activity that entities of the first of these sorts carry out." (p. 101) Schatzki thus also gives primacy to human agency.

Elaborating on social worlds by illustration, Schatzki characterizes day trading as a "practice-order bundle" or complex and the overall day trading industry as a "confederation of nets of practice-order bundles." (p. 169) Further, and importantly, day trading itself is seen to *cohere* with the practice-order complex of day trading firms, while it *competitively intersects* with the practice-order complex of professional market making. The different practices and their

routines are intricately interwoven. For instance, even within a single day trading firm, a range of practices, associated with marketing, law, planning, accounting, technical operations, education, and support, are carried out through interlocking routines. In the case of the professional market making complex, it provides the competitive opportunity niche and the context for day trading through the price spreads with which it works. Its own routines are aimed in part at thwarting the exploitation of spreads by the day trading industry, which can drain its profits. The broader point in this case illustration is that practice-order worlds are constituted by both cohering and competing practices. The advancement of any one practice takes place in such settings.

Relying thus on Schatzki, we can summarize now by cobbling together an overarching perspective, in which technology as routine capability finds its place. We will say that technology manifests itself in four constitutive and contextual spheres: those of worlds, practices, routines, and devices, as portrayed in Figure 1. The nesting of the spheres indicates the relatedness. From the outside in, first, the various worlds in which we live and work are shown as substantially constituted from our human practices. At the same time, these worlds provide the contexts for the advancement of practices. Second, similarly, our various practices are constituted largely from families of routines that provide capabilities. Routines are themselves developed in the context of human practices. Indeed, following Schatzki, routines presuppose practices (p. 96). Third, routines are substantially constituted from devices that provide affordances. Devices not embedded in other devices provide affordances only in the context of routines.

<Insert Figure 1 about here>

From the vantage point of this perspective, we next explore technological development and change. We consider how our insights, derived from a view of technology as routine capability, complement those of Arthur in his discussion of technology as devices.

What changes technology?

What changes technology as routine capability? How does technology develop from this perspective? And how does this differ from change seen from the device perspective? Following Schatzki, we will argue that technology develops largely as means to advance human practices. In this context, we identify and discuss three principal sources of change in both routines and devices: change by *design;* change by *execution*; and change by *diffusion*. As will be seen, change of each type entails the engagement of multiple cohering and competing practices. An additional source arises in *shift* in the practices themselves, in the ecological context in which they cohere and compete, which opens up (or closes down) opportunities for advancement.

Change by design

Change in technology as routine capability occurs often by design, just as with devices, as described by Arthur (2009). In the IT context, a good example is business process engineering (BPR) in the early 1990s, which focused on efficiencies attainable through better engineered routines (Hammer and Champy, 1993). The particular IT needed was determined in BPR from the new routine, in contrast to the ERP movement that followed in the late 1990s, where adoption of ERP software drove the choice of routines needed to employ it (Davenport, 2000). (The amused reader may be reminded of the question as to which comes first in new technology, the tool or the routine, which we now see is not an idle one and has practical ramifications.)

While BPR typically sought radical change, more modest changes in both devices and routines are undertaken through normal systems engineering, a practice well described by Arthur (2009). However, the design challenges faced are very different for devices and routines. With devices, a new or modified one must typically be *built* and tested. (Note here that the use of digital modeling for such purposes illustrates the redomaining of the engineering practice.) With human routines, such 'building" may be possible only in their ostensive aspects, where associated procedures are articulated and documented, in a form of *composition*. While instruction in procedures may also be given, the routines themselves remain "dead" until brought to life in performance, as described by Pentland and Feldman (2008). Too, the notion that prescribed procedures will (or even always should) be followed by human actors performing engineered routines has always been a shaky proposition, dating back to the early and controversial days of "scientific management" (Taylor, 1914).

Still, in the case of information systems as devices, they may serve as actants in routines and their software may highly circumscribe the actions of their human users, as with ERP systems. This is well illustrated too in electronic shopping, where, once a shopper proceeds to checkout, the transaction is concluded under strict system control, the terms of the transaction being pre-set by the selling party. (Pentland and Feldman (2007) provide a nice illustration of buying an airline ticket online.)

From a design perspective, it is notoriously difficult to anticipate the variety of situations that will inevitably arise for human actors engaged in their routines. With electronic shopping, for instance, a problem for sellers occurs when a new shopper, frustrated with her options, abandons her cart and takes leave of the site. Prescribed procedures tend to work best where reliability is paramount, actions are highly circumscribed, and exceptional situations are relatively rare. Even where execution appears simple on the face of it, problems arise, as illustrated in a very different non-IT context recently in preparations for the treatment of Ebola patients.

The hallmark of change by design, whether with devices as described by Arthur, or with routines, is the completion of the design cycle (Pentland and Jung, 2014). In the case of modern devices, change is *engineered*, and this involves some form of requirements specification, design, build and test, and release. With devices brought to market, this also involves preparations for production and distribution. In the case of routines, change involves composition and instruction. It also involves documentation and training, often lots of it. All this requires time with the consequence that change by design can be slow and lumpy, even with maintenance subsequent to initial implementation.

Change by design, whether for devices or routines, thus takes place through multiple practices which support it, which require their own technologies and expertise. Thus, system engineering is a practice often quite differentiated from the practices supported by the systems themselves. Still, any design practice must cohere with its supported practices. Advances in system engineering practice are often aimed at facilitating the change process in implementation, as with the development of newer "agile methods" (Boehm, 2002).

Importantly, whether designed or not, once performances begin, even as "dress rehearsals," routines will originate and coalesce rather quickly around the introduction of new devices. *Improvisation* in actions will follow as a reminder that designs and devices by themselves cannot deliver routine capabilities. Too, in certain situations, as in the Ebola case, there may be little or no time to solve problems through the design cycle. Routine capabilities must often be achieved in routine execution, on the spot.

Change by execution

As organizational research has established, and improvisation suggests, routines are not fixed, but rather adapted to situations arising in their repeated execution. Every performance, then, presents an occasion for adaptation, through the appropriation of a new device, for instance, or the introduction of a new move by users interacting with machines, or with a fix to software driving such interaction, sometimes as a quick repair, or, eventually through the design cycle. In change by execution, then, devices must be operated and maintained, while the routines that employ them achieve greater capabilities through improvisation as needed and desired.

Technology as routine capability is thus *learned* and changed most basically through repeated performances. Pentland and Jung (2014) posit that routines change through a recombination process in repeated execution, following Arthur (2019), who posits that devices are changed through recombination in the design cycle. While the change processes associated with devices and routines are very different, they may thus introduce novelty in the same way.

The building of routine capability through repeated performances is more likely to be associated with gradual, incremental change, than with radical change, which is more likely to be undertaken via the design cycle, most suited to devices.

Nevertheless, change through repeated performances can be subtle, complex, and far-reaching. Routines are not typically performed in isolation, as part of an isolated practice, but rather in concert with other interlocking routines associated with multiple, interwoven practices, as Schatzki would remind us. Even within a single firm, the use of ERP is coordinated across multiple functions, each with its own practices, often operating in separate "silos" as seen by an often frustrated management. The use of extended ERP, incorporating supply chain management (SCM) and customer relationship management (CRM) of course compounds the complexity of execution further. The adaptation of interlocking routines through repeated performances within and across firms and multiple practices is thus a substantial challenge.

Interestingly, where IT is involved, the devices associated with routines can sometimes be maintained even during routine performance, between related routines for instance. A good example is the automatic update of Windows software between use sessions. Physical changes to devices during their operation are more likely to be problematic. Still, parts may sometimes be quickly swapped, as with battery replacement. More generally, of course, users have tinkered with their tools in working with them, since tools were first devised. Users have always sought greater affordances from their devices. Tinkering skills are thus incorporated in routine capability.

We note that technology as routine capability changes even without changes to the material devices themselves. For instance, a device employed in one routine may be repurposed for use in another. Pentland and Jung (2014) describe how cell phones came to be used in positioning routines.

Where devices are thus flexible in their use, new routine capabilities may be achieved entirely by their users. However, this may also spark redesign of the device to capitalize on these new capabilities, as illustrated by the emergence of the smart phone from the ordinary cell phone.

Change by diffusion

Importantly, a single routine performance is local to the social unit undertaking it. Whether incremental or radical, change in technology as routine capability is thus first locally achieved. It may then eventually diffuse, while undergoing further adaptation, to the broader population. Device vendors may facilitate this process by incorporating supportive changes to their products. The ostensive aspects of the associated routines, i.e. the articulation of the capabilities to be achieved, will underpin the communications associated with this diffusion.

Consultants are likely to play a significant role, helping each of their clients achieve routine capabilities associated with what are understood to be best practices (Swanson, 2010). The underlying diffusion mechanism is largely one of adaptive *imitation*. The overall process is one of *community learning*, as described by Wang and Ramiller (2009) in the IT context.

Again, ERP provides a useful illustration. Originally conceived for the manufacturing industry and larger firms that could bear its costs, the software was gradually adapted for use in smaller firms and other industries and was over time diffused accordingly. Consultants facilitated the vast implementation process, often using "templates" to aid in introducing the necessary new routines.

In change by diffusion, then, the challenge for device makers is to *distribute and extend* their wares to the broader population. The opportunity is to capture a significant share of the new and growing market. Each competing provider trumpets the features of its own product or service, as well as the compelling advantages of the new technology, to the buying audience. These advantages will typically be articulated In terms of capabilities that the devices bring.

From the adopter perspective, however, the advantages come not from the devices, but from the routine capabilities they must themselves achieve. And the majority is most likely to commit to the technology, where the evidence is that those who have already done so have been successful, such that broader practices are being changed, and one cannot afford to be left behind. Accordingly, they seek to learn from others and *replicate* successful routines and experiences.

Thus, radical change in technology as routine capability may arise through conscious effort to advance a practice in a new way. Again, such effort may first be local, for example, when a firm seeks to innovate for competitive advantage, which may or may not be sustainable once others follow its lead. But radical change may also be sought globally among many social units all at once. Historical examples in the financial industry include the establishment of bank ATMs and their networks (McAndrews, 1991). In the health care industry, a current example is the establishment of insurance exchanges, both state and federal, under the U.S. Affordable Care Act. Massive changes in routine capability are characteristic in each of these illustrative cases.

We note that radical change may occur more swiftly where adopters are independent, achieve routine capability relatively easily, and where network effects are supportive, as with the individual adoption and diffusion of Twitter. Radical change among organizations is in general a more challenging proposition. Adoption requires an organizational rationale, routine capability must be collectively achieved, and network effects may or may not be in play. It typically proceeds less swiftly, notwithstanding much early experimentation with new devices promising new rewards.

However swift the change by diffusion, where routines are concerned an important aspect is their *normalization* and institutionalization. The greater the social sweep of adoption, the more likely the routines, if not the full capabilities, will eventually be roughly common across players, even with continued local improvisation and adaptation. And so practice is changed with new technology for the many, not just the few.

Change by shift

Changed practices are not permanent, however. The large variety of human practices and their associated routine capabilities coexist in an ecology of sorts, in which they both complement and compete with each other for our time and efforts. As is well known, not all practices persist endlessly or with the same frequency or intensity, or even in the same locations. While new ones originate and flourish, as with financial engineering, web design, and blogging, for instance, others wither and recede, as with stenography and professional typing, or morph into something else, as with typesetting and bookkeeping, or fall away altogether, as with telephone switchboard operation. So too do associated routines and capabilities, as performances increase, or diminish or even cease. All this also takes place at varying paces around the world. We refer to this process of practice ebbs and flows, contractions and expansions, and the emergence and development of new practice mixes, as change by ecological *shift*.

In economics, the kind of shift we are talking about is often discussed as change marked by innovation, entrepreneurship, and "creative destruction," dating to the work of Schumpeter (1912). Much of this work focuses on change and upheavals among industries and the fortunes of firms and their products and services. More recent work in evolutionary economics emphasizes the importance of knowledge and skills in achieving firm performance. Useful knowledge and skills are seen as unevenly distributed in the economy. Too, the profit motive stimulates this through continuous search for better goods and services and means of production. Useful knowledge and technology are "restless," and "there are always good reasons to know differently." (Metcalfe, 2010, p. 160) As a consequence, where technology is concerned, the economy can't be considered a system in equilibrium, as it is in neoclassical theory. Rather, it must be seen as dynamic, in flux, and as an ongoing problem-generating and problem-solving structure. It gives rise to what Arthur (2009) refers to as *opportunity niches* in motivating the development of new technology.

With devices, one opportunity may be a "disruptive" innovation that, through redomaining or reinvention, undercuts a dominant product's economic position (Bower and Christensen, 1995). In the case of ERP, SAP's R/3 product, which moved a mainframe-based product to one employing newer and more popular client/server and relational database technologies, offers an illustration.

Again, opportunity niches exist not only for the introduction of new devices. They exist for the development of new routine capabilities, even with existing devices. Socially, in our human practices, we are as restless for new ways, as we are for new devices. Both motivate the development of new technology. Both provide the motivation underlying resulting change by shift.

Of course, routine capabilities are important not only to firms. They are important to people that help build them and engage in them and to society more broadly. Thus, change by shift implies change in occupations, for instance, along the lines of our examples above. It also has broader social ramifications. A current example exists in journalism, where with the decline of the print newspaper business, fewer professional journalists are employed, with the consequence that less journalism altogether may result, with negative consequences for an informed public (see Carr, 2014). Still another example exists in higher education, where with MOOCs (massive open online courses), it is said that instructional efficiencies may lead to consolidation in this sector, with fewer opportunities for college teachers, and homogenized education for students, with less learning by traditional face-to-face contact (see Vardi, 2012). The tensions in both these prospective shifts might be illuminated by a focus on the associated routine capabilities of all participants, we suggest. In change by shift in practice, the broad challenge is to adapt and recreate.

However, we are aware of relatively little IS research that has addressed change by shift as we've presented it, even though it has and continues to be of great importance. Consider, for instance, the much-discussed off-shoring of IT jobs from developed to developing countries, and what this suggests for routine capabilities and where they exist, and whether they exist at the same or different levels. It would be interesting to review existing research on off-shoring to ascertain how it speaks to change by shift.

An important aspect of change by shift is that one shift likely implies another, in the ecological context. Thus, for instance, in holiday shopping, online shopping may increase and displace store shopping, at least in part. Retailers may struggle to find the balance from one year to the next. Newer practices may thus substitute in part for older ones. Restlessness ensures that associated routine capabilities will be in continuous flux and adjustment, in the advancement of human practices.

In sum, however technologies as routine capabilities change by design, or by execution, or by diffusion, they will change too by shifts in practices. Schatzki (2002), in his careful description of the origins and rise of daytrading on the NASDAQ, provides an excellent case example, at the practice level. Only through an understanding of shifts among related practices, are we able to grasp the significance and value of the associated routine capabilities, that is, of the technology itself.

We summarize our discussion of change in this section in Table 1, contrasting change in devices with change in routines. Each offers a rather different interpretation of change in technology. Arguably, each is incomplete without the other. From our overarching perspective, which incorporates both, this is easily understandable. The need to grasp technology as something more than devices is demonstrated.

<Insert Table 1 about here>

Discussion

Revisiting the question with which we began this essay, what comes first then in technology, the device or the routine? While the extent literature suggests for the most part, that it is the device, to the neglect of the routine, we have sought here not so much to reverse the order, as to bring routines to the foreground of the story. We have argued that changes in routines can lead changes in technology, as much as can changes in devices. Changes in each anticipate changes in the other.

We have sought here to elaborate on the technology story offered by Arthur (2009), which focuses primarily on devices. Relying on Schatzki's (2002) practice theory, we have developed an overarching perspective that incorporates devices with routines, routines with practices, and practices with worlds. In our elaborated technology story, the affordances of devices are seen as manifested in routines, while the capabilities of routines are manifested in human practices, which thrive or not in their respective worlds.

When we observe that our larger global world seems saturated with devices then, our overarching perspective explains why. Technology is only served by devices. It is delivered in the form of routine capabilities. These in turn are constitutive of our human practices, which we seek to advance. When we look about at all our devices, we need only ask, "What are we trying to do here?"

While technology is our focus, we note that our overarching perspective also speaks to those interested primarily in routines. Parmigiani and Howard-Grenville (2011), in a recent review, contrast research on routines from the capabilities and practice perspectives, observing that "researchers in each group seem to be having parallel conversations" that do not speak to each other. (p. 414) They suggest that scholars address how these two perspectives interconnect. Our own overarching perspective on technology provides one answer. Curiously, much of the reviewed research on routines seems little concerned with technology, however.

D'Adderio (2011) in her helpful review of routine theory calls for bringing artifacts to the center of routines and suggests several steps for doing so. She identifies software and information systems, in particular, as important to theorize in these terms. Nevertheless, in

accommodating artifacts, she anchors her suggestions firmly within routine theory, rather than in a larger technology story within which routines are themselves anchored, as in our own perspective. Similarly, Pentland (2014), in his promising new work, positions technology as artifacts within routine theory, elaborating on the narrative network model (Pentland and Feldman, 2007).

Our examination of technological change in devices versus that in routines offers additional insights. Four sources of change—design, execution, diffusion, shift—are identified and provide for an integrative view. In the case of change by design, we have pointed out the problems associated with applying the design cycle to routines, as compared to devices. As routines are fully realized only in their performance, their design might be said to be incomplete, pending execution (Carroll, 2004). In the case of change by execution we have described how routines can be altered with each performance, while devices are typically less adaptable, though more so where they are digital. Learning by doing is largely local to a routine's performance, however, presenting challenges to adoption of the technology more widely. In the case of change by diffusion, we have argued that adoption of devices must be differentiated from the collective building of a population's routine capabilities, which requires community learning through an infrastructure of supporting practices. Whatever routine capabilities are achieved, they and their devices remain vulnerable to shifts in associated practices, however. In the case of change by shift, we have suggested that ecological shifts among practices and their routines follow from a restlessness similar to that described for an evolutionary economy and devices offered in the marketplace. Following Schatzki, we would argue that evolutionary practices are primary in the overall change process.

The four change sources are of course linked with each other. Change by design is imbricated with change by execution much as described by Leonardi (2011). Both are intertwined with change by diffusion, as capabilities accumulate more broadly to a population. Change by shift provides ongoing impetus to the process, opening and closing opportunity niches for advancing human practices.

Broadly, a *new technology*, then, is a capability forged from introducing new devices and routines to a human population and its practices. The notion that a technology is *forged* is the idea that it is brought into being and given its shape by a community of stakeholder actors. These include the providers of the technology's devices, the builders of its routines, and a host of other players and promoters of new technology and its diffusion, who bring institutional infrastructure in support (see, e.g., Swanson, 2012). A greater understanding of these actors and their collective interactions is essential to a better understanding of how technology is developed in the interest of advancing human practices.

In summary, we claim that while the role of new devices in technological change is relatively well understood and represents the conventional view, the role of routines is less so and has been masked in everyday understandings and much of the literature. We have sought here to unmask it.

Our view of technology as routine capability offers a new or at least reworked perspective, from which to conduct future research on technology and how it underpins most of what we do, as well as where we are presently going with it. It suggests that this research be grounded in several ways, so that it may be understood in the context of the larger picture sketched here. Most of the needed research is likely to be case research, though not always of the traditional kind.

Traditional case research typically addresses contemporary adoption of a single technology in a single organization, often focusing on implementation issues and whether they have been overcome. Its general prevalence no doubt reflects the situational opportunities that come to the researcher, as well as the abundant interpretive stances that may be taken. Where focused on routine capabilities, it can continue to offer insights. It might be sensitive in particular to individual and organizational *actions*, and how they both constitute routines, and are enabled by them. From a routine capability point of view, *we are essentially what we are able to do*. We are not our devices or tools. Nor are we only actors. Rather, employing our devices, executing our routines, we act collectively with consequence. The study of how all this comes together as a technology, even in the single organization, continues to be of importance.

But beyond this, we especially encourage case research that departs from the traditional model. In particular, we encourage (1) studies of multiple technologies whose developmental paths are intertwined; (2) studies with a substantial historical dimension; and (3) studies that relate technology change in terms of routine capabilities to ecological shifts in practices.

Boland, Lyytinen, and Yoo (2007) provides an exemplary study of the introduction of digital 3-D technologies in Frank Gehry's architectural practice, speaking to all three of these suggestions.

Studies of multiple technologies are necessary to discern path dependencies in the evolution of routine capabilities. In the case of ERP, for instance, it is known that it was conceived as a "next generation" MRP (Manufacturing Resource Planning). However, while there is a literature on each in its own time, we are aware of no study that has systematically examined the emergence of the one from the other, although anecdotal accounts exist. Swanson (2015) offers a sketch, drawing from several sources. Applying a routines capabilities perspective to this transition might help us build theory here.

A substantial historical dimension is also necessary to guard against inferences drawn only from present and sometimes transitory circumstances. Many of our ERP studies have been very

much of the moment, in particular those that documented with little time lag the notorious implementation problems that arose in the late 1990s, when there was much excitement about them. Now that collective routine capabilities have been largely achieved with ERP, it might be fruitful to ascertain more closely what this amounts to, and how it came about over the years.

Williams and Pollock (2012) similarly call for taking a historical approach to enterprise systems, through the building of a "biography." See too Pollock and Williams (2009).

Studies that are situated in shifts in practice are most likely to be revealing of how technology initiatives are purposed. In the case of ERP, it would be interesting to examine whether its ongoing development over the years reflects the broad expansion of services in comparison to manufacturing. In the U.S., the present shifts in health care services and insurance practices, offer significant opportunities for study of new technology arising in the associated opportunity niches.

Finally, because a technology is viewed as accruing, not only to the single organization, but to a larger population, such as an industry, or a profession, or a nation state, studies that shed light on the acquisition of routine capabilities in these contexts would be especially welcome. Only by raising our research sights to these levels, are we likely to grasp the "tsunami" of technology now sweeping over us. In the present paper we have sought to reframe our view of technology with this uppermost in mind.

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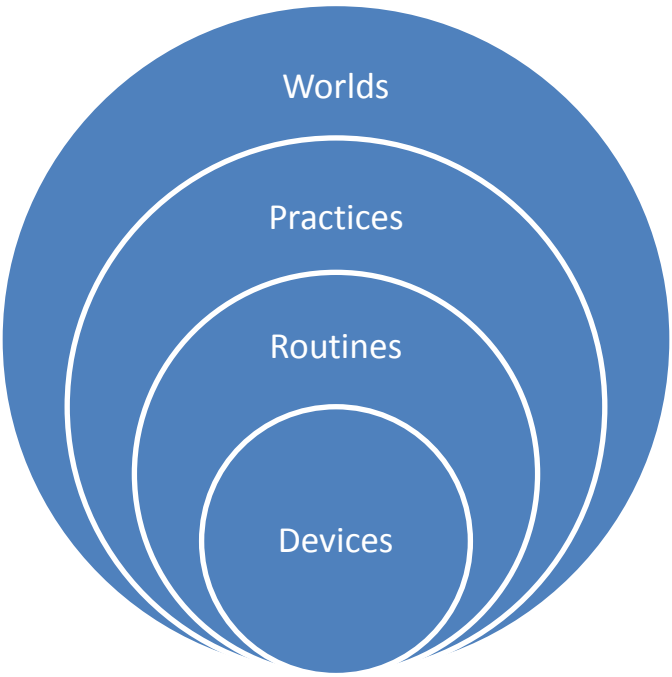
Figure 1

Four Spheres of Technology



Explanatory key: Technology manifests itself in four constitutive spheres: those of worlds, practices, routines, and devices. The nesting of the spheres portrays their relatedness. From the outside in, first, the various worlds in which we live and work are substantially constituted from our human practices. At the same time, these worlds provide the contexts for the advancement of practices. Second, similarly, our various practices are constituted largely from families of routines that provide capabilities. Routines are themselves developed in the context of human practices. Third, routines are substantially constituted from devices that provide affordances. Devices not embedded in other devices provide affordances only in the context of routines.

Table 1

Technological Change in Devices and Routines

CHANGE SOURCE	DEVICES	ROUTINES
DESIGN	Build and test	Compose and instruct
EXECUTION	Operate and maintain	Perform and improvise
DIFFUSION	Distribute and extend	Replicate and normalize
SHIFT	Redomain and reinvent	Adapt and recreate

Explanatory key: Technology changes through four processes: design, execution, diffusion, and shift in practices. Each involves learning which is necessarily different for technology as device and technology as routine. *Change by design* is creative in nature. By whatever means, a new device is built and tested. A routine, in contrast, is composed and instruction is offered. *Change by execution* occurs in activation of the technology. A device is operated and maintained. A routine is performed and improvisation is undertaken as needed. *Change by diffusion* occurs with spread of the technology to a wider population of adopters. A device is produced in quantity and distributed and extended in its features. A routine is replicated from place to place, and normalized in its conduct. *Change through shift* occurs as practices ebb and flow, advance and decline, among other practices. A device may be redomained or reinvented to meet changing needs. A routine may be adapted or recreated. In both cases, new design cycles may be initiated.