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Communications of the **A**ssociation for **I**nformation **S**ystems

THE U-CONSTRUCTS: FOUR INFORMATION DRIVES

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ABSTRACT

Facing a world of ubiquitous networks and universal devices, a world in which users can access networks at any time from any place using a range of devices to invoke unique and personalized services, it is time for IS researchers to take a new look at past, current, and future information needs. This article elaborates and extends several concepts that lay the foundation for thinking about next-generation information requirements. Specifically, four information drivers are identified that form the underlying cornerstones of our ideas. These drivers, which we call the u-constructs, euphonically comprise ubiquity, uniqueness, universality, and unison.

KEYWORDS

u-commerce, u-constructs, ubiquity, uniqueness, universality, unison

I. INTRODUCTION

All species process environmental information to solve the fundamental problems of survival and reproduction identified by Darwin [1968] in his theory of evolution. A few species develop information systems to support solving these problems. For example, bees perform an information dance to communicate the distance and direction of food [Wilson, 2000]. One species, *Homo sapiens*, has excelled at information systems creation, and these systems have evolved to solve increasingly complex problems far removed from Stone Age issues of survival and reproduction.

The elegance of Darwin's thesis, arguably the most important scientific opus [Dennett, 1995], is that it rests on a small set of concepts. Could it be that there is similarly a small set of concepts that underlie humans' desire for information and thus provide a conceptual foundation for understanding information systems? In this article, we put forward a case for a foundational set of concepts that we argue drives the advancement of information technology. Our thesis is built upon the co-evolving nature of task, technology, and information systems, and we start with the very dawn of civilization.

In order to solve the fundamental problems of survival and reproduction, humans had to successfully execute basic tasks such as hunting, gathering, and preparing food for eating.

Evidence exists that around 2.5 million years ago, our ancestors were using technology to improve task performance. They were using 'hammerstones' to produce sharp-edged flakes by striking certain types of rocks at a particular angle [Klein and Edgar, 2002]. These flakes were used for butchering or cutting up the muscle mass of animals. Task and technology, no matter how basic, always have a partner—an information system. Flake making and use could not have survived unless flake makers had trained others how to select the right rocks and strike them appropriately. Similarly, butchering skills had to be transmitted. As humans developed technology, they needed to find ways of communicating the information about that technology to successive generations.

The trinity of task, technology and information systems (Figure 1) interacts and co-evolves in a cycle of innovation of task improvement. A task (e.g., preparing food) drives development of technologies (e.g., flake making and butchering), which drives development of an information system to communicate knowledge of the technologies. Technology, in turn, creates new tasks. Thus, in our example, butchering emerges as a human task, which then acquires its own technology (types of flakes for different aspects of butchering) and information system. Similarly, communicating butchering skills is a new task that results from using the information system.

Figure 1. Task, technology, and information systems cycle of task improvement

Information systems have long been a part of human life, and breakthroughs in information technology (e.g., new ways of performing the communication task) have been critical to the development of civilization. The pivotal events in the history of mankind have been those that have significantly altered humans' ability to transmit and receive information (see Table 1). New information technologies, such as the alphabet [Shlain, 1998], have had tremendous impacts on civilization. Digitization, the foundation of the current information revolution, started with the Jacquard loom in 1801 and was followed by the telegraph and Morse code in the mid 19th century.

A fundamental issue that concerns our discipline is to determine the long-term, or ideal, goals that underlie this trajectory of improved information communication. What are the fundamental desirable characteristics of information and information systems? What are the basic human needs for information?

We believe that the four elements of u-commerce [Watson, et al., 2002] (ubiquity, uniqueness, universal, and unison) reflect these ideal goals. Because we extend these elements beyond their original conceptualization in the domain of u-commerce, we refer to them as "u-constructs." Watson et al. [2002] derive the u-constructs by looking at recent trends in information technology innovation. We believe that these u-constructs are not new, but are latent human information drives—in the same way that there are four fundamental drivers of human behavior (acquire, bond, learn, and defend) [Lawrence and Nohria, 2002]. However, evolution and innovation are not well-charted paths, and latent constructs may not be visible until the journey has progressed some distance. We believe that after more than a century of digitization, we are now at the point where

the u-constructs have become apparent. However, as we will show, there is evidence prior to recent times that humans sought to develop information system that incorporated some of the u-constructs.

Table 1. Human Information Technology Revolutions (Source: [Watson et al., 2002])

Signing
Drawing/Painting
Speaking
Writing
Alphabet
Arabic numerals
Printing technology
Digitization
Photography
Motion pictures

Fundamental constructs come not from prior theory, but from observation and reflection. As the antecedents of other constructs, their presence is revealed by a carefully constructed train of reasoning supported by observation. In this article, we derive the u-constructs by analyzing recent transitions in commerce and bolster our case with historical evidence.

II. THE EVOLUTION OF COMMERCE AND THE U-CONSTRUCTS

The u-constructs first emerged from envisioning the development of commerce based on recent innovations [Watson, et al., 2002], and this is also our starting point. Conceptually, this next-generation commerce, also called u-commerce [Watson, et al., 2002], can be viewed as the logical extension of e- and m-commerce (Figure 2). It represents the next (and still emerging) phase of commerce—initiated by e- and propagated by m-commerce. The core of this vision is simple: overcoming spatial and temporal boundaries, which has been an imperative of many information technology innovations. For example, writing overcame the spatial and temporal limitations of oral transmission.

Kant recognizes that both time and space have unique characteristics. They are applicable to physical things, but they themselves are neither entities nor processes that can be observed [Kant, 1787]. Rather, they form a framework for entities and processes that is needed in order to grasp the world as a whole and capture it in the form of information. Time and space are fundamental dimensions of human existence [Lee and Sawyer, 2002]. Everything humans do is situated in a time-space framework [Kant, 1787], and we contend that each major information revolution has been aimed at enabling information to escape, directly or indirectly, these time and space constraints. Writing is superior to oral transmission because it transcends the time and space limits of speaking. Printing enhances writing because it introduces economies of replication and further loosens the shackles of time and space.

Human communication innovations have targeted time and space constraints for epochs. It is apparent that we desire a world of information unhindered by these confines. Recent technological developments enable us to foresee attainment of this long sought aspiration. Thus,

as we posit a world of information systems that has overcome time and space limitations, we can think about dimensional endpoints. As will be demonstrated later, the u-constructs have the potential to form such boundaries and can be used, for example, to classify existing as well as future information systems.

Figure 2. Stages of commerce

One learns about evolution by studying prior species and transitions that occur when the environment is perturbed. For example, abrupt climactic changes have a significant impact on species [Weiner, 1994; Calvin, 2002]. In our case, we examine technological disturbances on the development of commerce in order to derive the u-constructs. The profit potential is a powerful innovation engine, and in the age of open, integrated economies [Wolf, 2004], new information technologies greatly influence the tasks of commerce (e.g., buying, selling, advertising, customer service). As we are primarily interested in the perturbing technological factors that influence the transitions between different stages of commerce, we scrutinize the various characteristics that differ between stages. Thus, Figure 2 is our sequence of examination. However, and contrary to what is depicted, we neither speculate that m-commerce replaces e-commerce nor that u-commerce replaces m-commerce. Rather, we see u-commerce as an encompassing concept that is a superset of both. In the following, we first examine the transition between e- and m-commerce, followed by studying the switch from m- to u-commerce. By doing so, we carve out characteristics that are inherent to each stage of commerce. This, in turn, paves the way for singling out the u-constructs.

FROM E- TO M-COMMERCE: WHAT IS DIFFERENT?

Before elaborating on the transition that takes place between e- and m-commerce, we first have to define these forms of commerce. Since the phenomenon of e-commerce has received a great deal of attention in IS research over the last few years, we simply present a working definition that will be used for the purpose of this paper. E-commerce is the “use of Internet technology for communications and transactions between an organization and its various stakeholders to improve organizational performance,” with stakeholders including customers, suppliers, governments, financial institutions, managers, employees, and the public at large [Watson et al., 2000; Straub and Watson, 2001].

Mobile commerce has a number of rubrics. It is sometimes referred to as “wireless commerce” [Kannan et al., 2001], “mobile business” [Dekleva, 2004], “mobile informatics” [Dahlbom and Llungberg, 1998; Sørensen, 2003], or “mobile e-commerce” [Tarasewich et al., 2002]. For some authors the adjective “wireless” is different from “mobile.” Whereas “wireless” refers to the form of transmission (i.e., data are exchanged across airwaves and do not require a physical cable), the term “mobile” is used in order to refer to applications that support users “on-the-move” [Varshney and Vetter, 2000]. In the same vein, for some authors the terms “commerce” and “business” are different in the sense that “commerce” implies a commercial transaction, whereas “business” does not. The same definitional problems occur (and have been addressed) in the context of e-commerce and e-business. For the purpose of this paper, we use the term m-commerce (as does the majority of authors, as well as the first journal paper in the area by [Varshney et al., 2000]), and we assume that m-commerce can be used synonymously with all the aforementioned terms. In analogy to our e-commerce definition, we define m-commerce as the use of wireless

technology for communications and transactions between an organization and its various stakeholders to improve organizational performance.

After defining the terms e- and m-commerce, we now examine their difference. Compared to e-commerce, m-commerce has some features that make it distinct [Zhang and Yuan, 2002]. They comprise five clusters: portability¹, reachability [Skiba, et al., 2000], accessibility [Müller-Verse, 1999; Buckler and Buxel, 2000], localization [Müller-Verse, 1999; Buckler and Buxel, 2000; Skiba, et al., 2000], and identification² (see Figure 3).

Figure 3. The e- to m-commerce transition

Portability

Portability comprises the physical aspects of mobile devices that enable them to be readily carried for long periods of time. We deliberately use the term “mobile device” to cover the aspect that extends beyond cellular phones, which form only one end of the spectrum, providing a small, lightweight device for voice (and data) communication. The other end is formed by wireless laptops, providing multi-purpose capabilities at the cost of a bulkier device. Along that spectrum, we also find smart phones, communicators, personal digital assistants (PDA), etc. line up accordingly. This list is a snap-shot of some of the current products available. One can expect the range and form of mobile devices to proliferate in the near future. Nevertheless, all mobile devices have, and will have, in common the motive of striving for portability while maximizing capabilities.

Among the five characteristics, portability has a unique standing, because it enables the other four constructs to be unique and distinct from the traditional e-commerce setting. Reachability, accessibility, localization, and identity are inherent characteristics of the mobile world if—and only if—they occur in the context of portability. As such, portability is the underlying characteristic that causes a quantum shift from e- to m-commerce.

Reachability

Reachability covers the idea that a person can be in touch with and reached by other people 24 hours per day, 7 days per week, assuming that the mobile network coverage is sufficient and the mobile device is switched on. Nevertheless, people have the possibility to restrict their reachability to particular persons or times. With network technologies such as GSM (Global System for Mobile Communications) or CDMA (Code Division Multiple Access), mobile devices

¹ [Skiba et al., 2000] refers to this as “form factors.”

² [Müller-Verse, 1999] refers to this as “security.”

require a user to initiate actively a session and invoke an application, just like an Internet session. However, with technologies such as GPRS, EDGE, or even UMTS/CDMA2000, users will stay connected permanently, without explicitly establishing a connection.³

In an e-commerce setting, reachability is limited to the computer level, or rather the plug-in level. An Internet user is reachable only (in synchronous terms) when sitting in front of a computer that is plugged into an Internet socket.

Accessibility

Accessibility describes the case where a person can access the mobile network at any time from any location, again assuming adequate mobile network coverage. In contrast, accessibility in an e-commerce world is limited to the plug-in level.

Localization

Localization describes the ability to locate the position of a mobile person or entity. As such, localization is key to providing geographically specific value-added services (so-called location-based services) and is expected to be the most distinct characteristic of m-commerce compared to e-commerce. Location-based services are any services that take into account the geographic position of an individual. These services may include geographic information about the individual himself (e.g., for navigational purposes), or location information about others (e.g., for finder services that let mobile users locate friends or family, businesses, or landmarks) [Barkhuus and Dey, 2003].

Mobile networks are able to determine the physical position of a mobile user at the cell level. From a technological point of view, this is to ensure a reliable connection when a mobile user roams across cell boundaries. Apart from this, technologies exist that are able to pinpoint the geographic position with a greater level of accuracy than provided through cell-based approaches. Examples are positioning systems that make use of satellites, such as GPS (Global Positioning System), or that base their localization capability solely on terrestrial network information (such as EOTD, TOA, etc.) [Giaglis, et al., 2002]. In 1996, the Federal Communications Commission (FCC) issued the E911 mandate intending to improve emergency responses to wireless 911 calls by determining a caller's longitude and latitude, with final implementation due by the end of 2005. The goal is provide the longitude and latitude coordinates of an E911 caller. Location accuracy has to be within 50 to 100 meters for 67% of all calls and within 150 to 300 meters for 95% of calls [Beinat, 2001; Federal Communications Commission, 2003]. As a consequence of the mandate, market reports forecast that by the end of 2007, location-enabled subscribers are expected to generate revenues of USD 5.9 billion in the U.S. [Mindbranch, 2005].

In an e-commerce setting, a person's geographical position cannot be determined at any point during the session. The only possibility is to identify a computer's physical IP (Internet Protocol) address, and based on that its physical location. This approach is not always applicable, because most networks use a dynamic addressing scheme.

Identification

Some second generation mobile devices employ a smart card as a secure form of authentication of the subscription and the mobile customer. The smart card, also called a SIM (Subscriber Identity Module) card, contains subscription and security related data as well as customer data,

³ [Müller-Verse, 1999] calls it "instant connectivity" and states it to be an m-commerce characteristic on its own.

and is plugged into the mobile device.⁴ By doing so, it decouples the identity of the mobile user from the device, allowing a user to switch physical devices without changing identities. The SIM card can be viewed as a virtual substitute of an individual's identity, containing personal and billing information.⁵ We, therefore, label this construct identity.

Contrarily, in an e-commerce context identity is always bound to a person's computer, i.e., it is device-dependent. Two approaches of identification are conceivable here: on an (1) application level, and on a (2) hardware level. On the application level, Internet applications can store limited information about a user's identity using cookies. However, due to the nature of HTTP (Hypertext Transfer Protocol), one cannot gather a consistent and comprehensive profile using cookies. In addition, actions such as users switching computers, or users deliberately providing false information, exacerbate the problem. One user may have multiple profiles for a single application. In this case, a unique identification from an application's point of view (or rather from a company's point of view) is not possible. On the hardware level, the IP address of the networked computer may reveal identity information. However, and as previously mentioned, dynamic IP addressing schemes may impair or even thwart this approach. Also, the approach of PKI (Public Key Infrastructure), supported through players such as NSA (National Security Agency), Sun Microsystems, Microsoft, etc., which was supposed to use public-key cryptography to set up a worldwide network of bodies authenticating digital signatures and certificates, failed due to its inability of reaching a critical mass of users [Judge, 2002]. Apart from the idea of identifying human individuals, RFID (Radio Frequency Identification) has gained considerable attention in the logistics industry. For example, Wal-Mart has introduced RFID as their future product identification mechanism of choice. By doing so, Wal-Mart also forces its 200 major suppliers to do the same [Kerner, 2004]. The German based METRO Group is currently conducting a comprehensive pilot project with 100 suppliers, 10 warehouses, and about 250 retail stores using RFID to track palettes along the entire process chain [METRO Group, 2004].

FROM M- TO U-COMMERCE: WHAT IS GOING TO HAPPEN?

U-commerce is *"the use of ubiquitous networks to support personalized and uninterrupted communications and transactions between a firm and its various stakeholders to provide a level of value over, above, and beyond traditional commerce"* [Watson, 2000; Watson, et al., 2002]. In other words, u-commerce describes a world that provides ubiquitous networks and universal devices, a world that not only presents an alternative view of space and time, but also transcends our understanding of m-commerce.

Major differences between m- and u-commerce appear at two levels. First, u-commerce is grounded in the four u-constructs, while m-commerce is mainly centered on wireless networked systems. The original writers on u-commerce [Watson, 2000; Watson, et al., 2002] escape the confines of a particular technology to broadly describe the characteristics of the next stage of commerce. For IS, this is an important development because scholars are more effective when they can abstract to a larger frame. Thus, it is not surprising that the original u-commerce work is forward looking because it has freed itself from technology to project where technology will lead.

Second, differences appear on the technological level because the u-constructs broadly frame a new environment. In understanding these differences, it helps to take an approach that has proven to be beneficial in the telecommunications field where the OSI model (Open Systems Interconnection) has served as a reference model for communication protocols. The core idea of

⁴ GSM is the only 2G mobile network that employs SIM cards. However, all 3G mobile network specifications include the use of SIM cards [Balderas-Contreras and Cumplido-Parra, 2004].

⁵ Network operators and providers authenticate new customers and verify their financial status before allowing them on the network. As a result, the personal information provided is usually highly accurate.

OSI is that the process of communication between two end points in a network can be divided into different conceptual layers, with each layer executing its own set of functionalities and relying on services provided by the underlying layers. The bottom layer, for instance, is responsible for a reliable data transmission, whereas the layer at the top is responsible for displaying transmitted data using the appropriate application.

For the purpose of this paper, we have adapted the OSI idea and structured our approach of examining the transition between m- and u-commerce accordingly. Even though mainly technical in its roots, we use the OSI classification to structure our thinking along its classification. Other IS researchers, such as [Varshney, et al., 2000] as well as [Kannan, et al., 2001; Agrawal et al., 2003], have used an analogous approach when conceptualizing mobile commerce. Particularly, our view encompasses: (1) mobile applications, (2) ubiquitous networks, (3) mobile devices, and (4) data synchronization. The different levels of abstractions help to reflect on dimensions that contribute or impair the degree to which m-commerce can finally lead to u-commerce.

Figure 4. The m- to u-commerce transition

Mobile Applications

Typically, mobile users manage to learn their mobile device's functionalities very fast, contrary to using a PC for the first time. This is partly because current mobile devices are limited in their range of applications: for instance, cell phones are mainly used for placing calls; PDAs are mainly used for personal data management, etc. Their limitation to specific applications is mainly due to technological reasons. New-generation phones, smart phones (a hybrid between cellular phone and PDA), have an operating system, thus providing a restricted version of a personal computer. Like a personal computer, smart phones offer a variety of mobile applications, ranging from email, to standard software packages, to Internet browsing capabilities, but require a new set of interface designs [Venkatesh and Ramesh, 2006]. With merging networks, devices and data, we expect mobile applications to span an even broader range of functionality and be universally usable, independent of the underlying network, data, or the device used. In short, in order to support mobile applications, we need ubiquitous networks and devices that are network independent.

Ubiquitous Networks

There is a heterogeneous landscape of mobile networks, ranging from analog systems at one end to digital systems of different generations (such as 2G, 2.5G, 3G, etc.) on the other. Even though the digital systems underwent a thorough standardization process, there are variations that typically differ in terms of the technical protocols and frequencies used [Varshney, 2003; Fjermestad et al., 2006]. As a result, for example, until recently, a typical U.S. cell phone was unlikely to work in Europe because of different underlying technologies. Since 2000, cellular phones are available that support all three versions of GSM, and due to Samsung's and

Motorola's effort, a chip has been created that bridges the gap between CDMA and GSM standards [Sundgot, 2003; Mobile Gazette, 2004]. Apart from 2G compatibility efforts, the first 3G network was launched in 2004 by UK-based mobile operator Vodafone [Arnfield, 2004]. Nowadays, 17 European countries deploy commercial UMTS [Carlsson et al., 2006].

Besides cellular networks, wireless local area networks (a.k.a. Wi-Fi networks) have become increasingly popular. The city of Taipei, for instance, presently has the world's largest Wi-Fi grid, providing free Internet access within the Hsinyi district [Reuters, 2004]. Wi-Fi access points have a shorter range than cell phone towers. However, they are currently able to provide transmission rates of up to 54Mbps. Bluetooth provides an even smaller range and is used to connect devices that are in immediate proximity to each other, such as laptops, printers, PDAs, etc. Based on these trends, we expect that future mobile devices will support multiple networks, as some already do, and will be universally usable across networks, applications and countries.

Mobile Devices

Mobile devices are needed to support mobile applications. Users can pick from a broad range of electronic tools to perform a certain task. This varies from cell phones to PDAs, to laptops, etc. With time, we expect more and more traditionally separated applications to be integrated into one mobile device. As can be seen already by smart phones, this trend will likely include combining cellular devices with "traditionally non-IS" devices such as jewellery or even clothes.

Data Synchronization

Ideally, mobile devices provide integrated and synchronized data. For instance, a phonebook stored on a cellular phone should not only match other electronic phonebooks stored on other (wired as well as wireless) devices, but it can also synchronize with personal calendars, to-do lists, etc. A data change in one application on one particular device should be automatically transmitted to all other associated applications and devices. Currently, however, due to heterogeneous networking standards, incompatible applications and devices, we still experience some limitations. Nevertheless, future developments in data integration will support a cross-network, cross-device, cross-application and even cross-group functionality. Groups and project teams need synchronization so that the latest version of their various electronic documents is always available. For example, IBM's Notes is currently used by many organizations to achieve group synchronization.

III. THE U-CONSTRUCTS

Up to this point, we have examined the different stages of commerce and their characteristics. We now pull all these characteristics together by carving out the fundamentals of the u-constructs and extending the earlier work [Watson, 2000; Watson, et al., 2002] on these concepts. Four higher-level constructs are identified: ubiquity, uniqueness, universality, and unison and can be described as follows:

Ubiquity = Reachability + Accessibility + Portability

Uniqueness = Localization + Identification + Portability

Universality = Mobile Networks + Mobile Devices

Unison = Mobile Applications + Data Synchronization

Some might view it as contrivance to have a set of euphonious constructs, yet ideas or memes compete for survival [Blackmore, 1999; Auger, 2000]. While the quality of an idea is important, and we maintain ours is, the ability of an idea to catch hold in the competitive conceptual marketplace is also an important consideration for authors. We all want our work to be remembered. Many are familiar with the 4-Ps of marketing or McKinsey & Co's 7-S model [Waterman Jr. et al., 1980] of organizational design because of the ease with which the idea is

recalled. Hence, we opt to enhance the recollection of the fundamental concepts we present in line with the early work [Watson, 2000; Watson, et al., 2002] that spurred our thinking.

UBIQUITY

Ubiquity incorporates the idea of accessibility, reachability, and portability into one construct. People are able to access networks at any time from anywhere, and in turn, are reachable at any time and any place. While reachability and accessibility provide the aspect of “any time” availability, portability takes care of the “any place” component. Thus, introducing a *truly* “any time, any place” level into our traditional thinking (Figure 5). GSS and CSCW research have introduced a two-by-two matrix with its dimensions of time and place [DeSanctis and Gallupe, 1987], each distinguishing between “same” and “different.” Interestingly, even though termed “different,” the model assumed that places are “dedicated.” In a ubiquitous world, however, information systems are not restricted in their usage to dedicated places anymore, but can be used literally everywhere: in cafes, trains, at airports, etc. As a result, we must add another dimension,—a “*truly* any time and any place” dimension (see Figure 5)—taking into account the portability aspect of future devices [Wiberg and Ljungberg, 1999].

Some authors have captured the idea of ubiquity under the label of “mobility” [Kakihara and Sørensen, 2002; Lyytinen and Yoo, 2003]. Conceptually both are very similar. Whereas ubiquity takes on the lens of the environment to provide the functionality for a user to move, mobility takes on the lens of a user being the active component in a ubiquitous environment.

Figure 5. Ubiquity continuum

Ubiquity, we believe, is not a new information goal, but one that has only become apparent when the destination is neared. Humans have always sought ubiquitous information access. For instance, rote learning, mnemonics, and books have been used for generations to enable ubiquitous information access. However, such technologies have limited capacity and concurrency is difficult to maintain. With every cycle in the trinity of task, technology, and information systems, one of the fundamental drives has always been to overcome spatial and temporal boundaries. In other words, any information system has been driven, to a greater or lesser extent, by the quest to conquer time and space. We therefore define ubiquity as *the drive to have access to information unconstrained by time and space*.

UNIQUENESS

Uniqueness is the idea of complete identification, not only in terms of identity and associated preferences, but also in terms of geographical position. As such, uniqueness incorporates the idea of identification, localization, and portability into a higher-level construct. Whereas identification provides an unequivocal person assignment, localization provides the geographical position component. Combining knowledge of who the person is with location-based services leads to the definitive level of uniqueness: we not only know who the person is, but also where

the person is. Thus, the ultimate level of uniqueness is achieved when a person in combination with his preferences can be uniquely identified in any context, i.e., across any time and space setting (see Figure 6). Tangible objects, as well as humans, have an identity, so we one can further extend the uniqueness concept. A palette of groceries, for instance, is a non-human object that often needs to be identified as well as tracked for logistical purposes. Companies, such as the German-based METRO Group or U.S.-based Wal-Mart are good examples that have implemented these features along their process chain with the help of RFID (Radio Frequency Identification) [METRO Group, 2004].

Figure 6. Uniqueness continuum

For human and non-human entities, an underlying idea of uniqueness is the ability to fully describe a physical object in a digital language. For humans, this includes characteristics, such as name, birth date, information preferences, day planning schedules, etc. For objects, it may include its tag number, size, color, temperature, location, etc. As with ubiquity, uniqueness is not a new information goal, but has been important to humans for a long time. For example, the British government passed the British Longitude Act of 1714 offering a prize of £20,000 (millions of U.S. dollars in today's terms) to anyone who could develop technology to compute longitude to an accuracy of 0.5 degree [Sobel, 1995]. Thousands of lives had been lost at seas because of navigation inaccuracies. Passports are used to uniquely identify travelers, and the term is probably derived from medieval documents required to pass through the gate ('porte') of city walls [Wikipedia, 2005]. In the days before photography, passports contained a physical description of the traveler. We define uniqueness as *the drive to know precisely the characteristics and location of a person or entity*.

UNIVERSALITY

Universality incorporates the ideas of universal usability, multi-functional entities, and interoperability (Figure 7). Until recently, the available collection of mobile devices was limited in its usefulness because they were not widely usable. For example, most U.S. cell phones were unlikely to work in Europe because of different standards and network frequencies, and vice versa. Furthermore, devices should be able to work with multiple networks (e.g., GSM, Bluetooth, Wi-Fi) so that customers have access to numerous access systems.

The idea of universality also incorporates the notion of multi-functionality. Devices often enter the market with a limited spectrum of functionalities (e.g., making a phone call). Increasingly cell phones, for example, are incorporating more functionality (e.g., camera, calendar, music player) so that we are likely to see the emergence of a universal information appliance that meets most of the mobile customer's needs. Instead of carrying several devices, people have one information appliance. We see a similar parallel in the software industry, where multifunctional products (e.g., MS Office) have eclipsed single function software (e.g., WordPerfect). If we approach universality with a broad perspective, we see that it envelops several important human endeavours. The push for global (e.g., ISO) and national standards (e.g., ANSI), COBOL, Java, and Esperanto are all examples of a human drive for universality. Currency unions (e.g., the Euro) are another form of information universality. As with ubiquity and uniqueness, universality is not a new information

goal, but has always been present. Overall, we define universality as *the drive to overcome the friction of information systems' incompatibilities*.

Figure 7. Universality continuum

UNISON

Unison embraces the idea of integrated data across multiple applications and devices so that people have a consistent view of their information, irrespective of the device used (Figure 8). Currently, unison is only apparent in a few examples. For instance, PDAs are able to synchronize with desktop computers; or email can be checked using different applications (e.g., different browsers or email clients). Unison extends beyond the individual to embrace cooperating groups (e.g., a corporate project team, a university class, or tour group) who need to have certain files or actions synchronized. For example, a tour group might have its schedule and wake-up alarms synchronized across each person's information appliance. Thus, when the tour leader makes a schedule change, the calendar of each member of the tour group is automatically changed and alarms reset as necessary.

Unison is also a latent information desire. For example, teams have always desired to have their documents aligned and have relied on technologies such as loose-leaf binders and photocopying to achieve this need. Thus, it is not surprising that the expression "all on the same page" is used to convey the need for unison within a group. In pre-literate societies, rhyme was used to ensure that everyone received the same message. For example, Ghenghis Khan's troops sang traditional songs into which words could be inserted to create an oral message that transmitted accurately across large distances [Weatherford, 2004]. Also, in the Christian world, Apostolic Church authorities introduced rituals, such as baptism and confession, centuries ago in order to establish a common set of rules that would regulate adherents daily lives [Koszarycz, 1997]. The basics of these rituals have survived until today due to a synchronization process across generations. Parents passed their rituals and beliefs from one generation to the next in order to keep the original faith and traditions alive. Thus, many groups and societies have an aligned set of beliefs and norms. In consequence, we define unison as *the drive for information consistency*.

Figure 8. Unison continuum

The u-constructs have not recently emerged; rather we believe that they have always been present as desirable characteristics of information systems. Due to their latent nature, these constructs had not surfaced earlier because we were too distant from the technology that enabled their realization. Humans were too far from the final destination to recognize the nature of their goals.

PARALLEL WORK CONVERGING ON THE U-CONSTRUCTS

Only a few researchers have contemplated next generation computing environments. We found two terms that steer in the same direction as the u-constructs: “ubiquitous computing” [Weiser, 1993a; Weiser, 1993b; Weiser et al., 1999; Gershman, 2002; Jessup and Robey, 2002; Lyytinen and Yoo, 2002] and “nomadic computing” [Kleinrock, 1996; Duda and Perret, 1997; Lyytinen and Yoo, 2003]. We now provide a brief description of these two concepts and illustrate how they relate to each other. In so doing, we provide further evidence that the u-constructs are fundamental information concepts.

The term “ubiquitous computing” was first coined by Martin Weiser [Weiser, 1991; Weiser, 1993a], who was one of the leading researchers at XEROX Parc. He worked for the Ubiquitous Computing Project created as early as 1988 [Mattern, 2003]. The project “speculated on a physical world richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives and connected through a continuous network” [Weiser, et al., 1999]. In a nutshell, ubiquitous computing embraces the idea of information processing devices being everywhere, embedded in everyday life in a non-intrusive and transparent manner. The Ubiquitous Computing Project started as a technology driven effort to create a vision of future computing environments. The project resulted in many fundamental patents and papers, mainly in the area of computer science, and included network protocols, operating systems, window systems, file systems, user interfaces, energy management, and input design [Weiser, 1993b]. While focusing on technological issues at first, it became clear that ubiquitous computing not only had the potential to reshape information technology as a whole, but also the way human beings interact, work and live.

Nomadic computing, on the other hand, was first mentioned in papers written in 1996 and 1997 [Kleinrock, 1996; Duda and Perret, 1997]. In order to achieve nomadicity, a “nomadic host should be able to move from place to place while operating as effectively as if it were connected to a fixed network” [Duda and Perret, 1997]. The resulting nomadic environment is a “heterogeneous assemblage of interconnected technological and organizational elements, which enables the physical and social mobility of computing and communication services between organizational actors both within and across organizational borders” [Lyytinen and Yoo, 2003]. Nomadic computing draws on three major drivers: mobility, digital convergence, and mass scale. Similarities and differences between nomadic computing and the u-constructs are examined in Table 2.

As can be seen by the definitions in Table 2, the drivers of “nomadic computing” and the proposed u-constructs are very similar in their conceptual underpinnings. However, a difference occurs in their terminology. Whereas “nomadic computing” puts the active part on the user side, the u-constructs put their emphasis on the environment in which a user operates. The same (terminological, but not conceptual) distinction is also reflected in the terms “mobility” and “ubiquity.” The term “digital convergence,” on the other hand, encompasses two u-constructs. First, universality, the convergence of mobile networks and devices in order to provide a seamless interplay; and second, unison, the capability of having an integrated, accurate and timely view on personal or group data, irrespective of the applications, devices, or networks used. As a prerequisite for universality and unison to occur, the u-constructs implicitly assume a mass scale adoption to take effect. Nomadic computing, in contrast, describes this aspect as an explicit component. If taken together, however, one can argue that the combination of mass scale adoption and digital convergence exactly map the joint idea of universality and unison. The

biggest difference between the concept of nomadic computing and the proposed u-constructs, as we see it, is revealed in the construct of uniqueness. The capability of knowing *who* a person is in conjunction with the knowledge about the person's whereabouts is not an explicit part of the nomadic computing concept.

Table 2. Comparison between nomadic computing [Lyytinen and Yoo, 2003] and u-commerce [Watson, et al., 2002; Junglas and Watson, 2003a]

Nomadic Computing	Comparable U-Construct
<i>Mobility</i> covers the idea of "emerging wireless and handheld computing tools [that] can be taken to different places and held in different places at ease, while still providing both access and adequate computational services." Mobility differentiates between mirco, local, and remote mobility.	<i>Ubiquity</i> describes reachability and accessibility combined with portability. Out of this, portability is the most comparable construct to mobility.
<i>Digital Convergence</i> captures aspects, such as Information can be stored in, transmitted by, and displayed using multiple devices and technology platforms. Several types of data can be transmitted and processed. Various devices share information and interoperate seamlessly while producing the service.	<i>Universality</i> describes the merger of mobile networks and mobile devices; <i>Unison</i> describes data synchronization for personal and group applications across multiple devices.
<i>Mass scale</i> projects massive increase in service volume, service types, and number of users.	Implicit prerequisite for the u-constructs to exist .
Not applicable.	<i>Uniqueness</i> represents localization and identification combined with portability.

IV. EXEMPLARY APPLICATIONS OF THE U-CONSTRUCTS

We have elaborated upon a set of four information drives: ubiquity, uniqueness, universality, and unison. We have demonstrated how they were derived and how they relate to parallel work in the area. In the following, we discuss how the u-constructs can be applied to enhance our understanding of IS. We have chosen two different settings in which the u-constructs potentially can make a valuable contribution. The u-constructs lay the groundwork for developing a taxonomy of information tasks. Following a discussion on the value of taxonomies, we apply both newly created taxonomies to our second case, the task-technology fit model.

EXAMPLE (1): A U-TAXONOMY FOR TASKS

Researchers often have failed to clearly distinguish between task and technology and have used both terms interchangeably. This is not surprising since solving a task has always been intertwined with using some form of technology. As already mentioned in the introduction, our own species has undergone exactly this experience for millions of years. A task (e.g., preparing food) drives the development of a technology (e.g., flake making), which in turn creates new tasks (e.g., butchering). Here, tasks and technologies interact and co-evolve in a cycle of innovation of task improvement. If the u-constructs are fundamental to our understanding of information systems, then they should also support a description of the types of tasks for which we use information systems. Our classification scheme builds upon identifying when technology ubiquity and uniqueness are desirable.

Tasks that require technology ubiquity are those that need to be executed immediately, irrespective of time or location. In other words, those tasks are *time-dependent*. Depending on whether the task is initiated by the task doer or triggered by an external actor, we distinguish between intrinsic (task doer) and extrinsic (external actor) tasks (see Figure 9). *Location-*

dependent tasks, in contrast, require location information either about the position of the user (intrinsic) or somebody else (extrinsic). The most appropriate technology used to perform these forms of tasks includes location-based services, i.e., services that track the geographical location of a person or entity. A combination of ubiquity and uniqueness enables location-dependency support. Finally, *identity-dependent tasks* require a unique identification of a user, including his preferences. Identity information can either be provided about the user (intrinsic, e.g., billing information), or about others (extrinsic), such as preferences for certain information.

The ability to receive in-store navigation while shopping is an example of intrinsic location- and identity-dependent tasks. Ideally, the mobile device knows about the user's preferences and informs him where each item is located (in relation to his geographical position) and if promotional offers exist for his favorite food [Wireless Newsfactor, 2003]. In the current description, this task has no time-dependent component. However, this component can easily be introduced when the person needs to be back from lunch break as soon as possible. Here, the system can tell him the most efficient route through the aisles, what cashier is currently idle, or has the least amount of items waiting. An example of an extrinsic time- and intrinsic identity-dependent task (with no location component) is a parking meter that accepts payment via a cellular phone [Reino, 2004]. In addition, the parking meter sends an SMS (short message) to the cellular phone when it is about to expire (time dependence) and asks its owner (identity dependence) if he wants to pay for an additional hour.

Figure 9. The information systems task cube

Traditional task classification schemes⁶ only partially incorporate these three aspects. For instance, the idea of time-dependent tasks is merely an implicit part of the category of "performance tasks" as termed by [Hackman, 1969; O'Neill and Alexander, 1971; McGrath, 1984]. Also, the idea of location-dependent tasks finds only partial support through the category of "spatial tasks" [Roby and Lanzetta, 1958], which comprises an event that is geographically distributed. Identity-dependent tasks, in contrast, do not have an equivalent in any of the traditional classification schemes. However, research on "personalized and adaptive content" [Zhang, 2003] shows that this category will gain importance in the near future.

⁶ A summary of traditional task classification schemes can be found in [Zigurs and Buckland, 1998].

THE VALUE OF TAXONOMIES

The preceding demonstrates that the u-constructs can help us to create an information systems task taxonomy. Since we aim to be futuristic and visionary (as recently requested by the IS community [Lyytinen et al., 2004]) rather than retrospective research, supporting the proposed taxonomies empirically seems infeasible at this point in time. Instead, we base our justification on the conceptual definition of taxonomies.

The term “taxonomy” has its roots in the Latin words “taxis” (i.e., tidiness, arrangement) and “nomos” (i.e., law). The practice of taxonomy reflects “the human instinct to organize its experiences and perceptions of the world” [Grove, 2003]. It does so for various reasons. One such reason that was (and still is) fundamental to human survival is classifying food into edible and non-edible, and situations into dangerous and non-dangerous. By using a taxonomy such as that presented, a human mind not only simplifies its mental processes, but also the effort of adding new experiences into the existing one. Furthermore, a classification scheme also allows communicating these experiences to others in a more efficient manner.

In the evolution of science, building a taxonomy was one of the most fundamental techniques of scholarship, particularly in the field of biology and chemistry [Grove, 2003]. Mendeleyev, for instance, created the periodic system in 1869 that not only arranged elements based on their physical and chemical attributes, but also identified properties of missing elements. In the adolescent field of IS, researchers have also established taxonomies. Ein-Dor and Segev [1993], for instance, derived a taxonomy in 1993 that identified 17 major types of information systems, using two dimensions: attributes and features [Ein-Dor and Segev, 1993]. Whereas the dimension of “functions” describes what an IS does (e.g., input, output, direct data storage, natural language understanding, etc.), the dimension of “attributes” focuses on the components of an IS (e.g., hardware, software, speech, natural language control, etc.). In their paper, the authors established matrices for function and attribute dissimilarities and applied multi-dimensional scaling in order to project future trends in IS evolution. One anticipated trend geared towards “autonomous intelligent machines (AIM)” that was expected to take on “the world’s physical work” [Ein-Dor and Segev, 1993] and would require sophisticated sensory capabilities. The other trend was expected to head towards “universal interface machines (UIM),” providing a communication interface that accepts the most convenient input (written or verbal) [Ein-Dor and Segev, 1993].

In general, the quality of a taxonomy is determined by the following criteria: (a) the level of including relevant attributes (and at the same time the level of excluding irrelevant attributes) [Ein-Dor and Segev, 1993], (b) the level of overlap among the attributes chosen [Ein-Dor and Segev, 1993], and (c), as pointed out before, the ability to identify missing entities. The problem of relevant and irrelevant attribute choice is a universal problem in all classification studies. Any classification system is arbitrary to some extent because its purpose is to condense, organize, convey, and permit the retrieval of usable information [Mayr, 1999]. To minimize arbitrariness, we kept the chosen attributes as parsimonious as possible. For instance, an extensive literature review was conducted that meticulously identified the differences between e- and m-commerce on one hand, and the difference between m- and u-commerce on the other. These differences were collapsed into higher-order constructs that are represented by the four u-constructs. Lastly, regarding the ability of identifying missing entities, the u-constructs have proven to be stable since their inception in 2000 [Watson, 2000]. New technologies that have emerged since then have supported the original set of constructs.

EXAMPLE (2): REVISING TRADITIONAL IS MODELS

The IS task taxonomy lays the foundation for thinking about traditional IS models in a new manner. Exemplary, the Task-Technology Fit Model (TTF) [Goodhue, 1995; Goodhue, 1998], one of the better known IS utilization models, is used to showcase the application of the u-constructs. TTF describes the degree to which a technology assists an individual when performing a portfolio of tasks. More specifically, it reflects the correspondence between task requirement, individual abilities, and the functionality of the technology. An information system will have positive

performance impacts if, and only if (a) it is used, and (b) the functionality provided by the information system fits the task the user has to perform. As such, rational users will choose tools and methods that enable them to complete a task with the greatest net benefit. In consequence, if a technology has exactly the functionality needed to complete a required task, it is more likely to be used and higher performance should result [Goodhue and Thompson, 1995; Goodhue et al., 2000].

Since its genesis, TTF has been applied to various technologies and settings, such as in the context of group support systems (GSS) [Zigurs and Buckland, 1998], software maintenance [Dishaw and Strong, 1998; Dishaw and Strong, 1999], and to measure performance impacts of an Integrated Information Center on end-users [Goodhue, 1997; Goodhue et al., 1997].

In our revised model of TTF, the u-constructs expand on technology characteristics. It is assumed that a rational user would choose *that* instantiation of u-constructs that are most suitable for the current task. In the case of time-dependent tasks, for instance, a rational user would choose a technology that is high on ubiquity, such as wireless technology. For location-dependent tasks, in contrast, where a user has to locate someone or something, a high level of uniqueness seems to meet the demand best. Along the same lines, for tasks where people must have the ability to switch seamlessly through different network zones (e.g., business people), high levels of universality are desirable; and for tasks where there is a need to invoke different kinds of applications while keeping an integrated view of data, a high level of unison is advantageous (e.g., system administrators). Parts of the proposed model in Figure 10 have been empirically tested [Junglas and Watson, 2003b].

Figure 10. Extended task-technology fit model based on [Goodhue and Thompson, 1995]

V. IMPLICATIONS

Information systems have been a part of human life for millions of years. We have always had a desire and need for information. What has been missing for so long is a comprehensive understanding of the fundamental drivers of our information needs. What are the latent drives that have propelled our incessant improvements in information technology? As information systems scholars we need to understand these intrinsic drives because they fashion the design of every information system we study, every information technology developed, and every information requirement. We present the four u-constructs as fundamental drivers of human information needs. We have endeavoured to capture all the fundamental drives and have explained them clearly. That is however unlikely, because science advances by elaborating and deepening initial germs of understanding into full blooms of knowledge. Thus, the most important implication of our work is that we have provided some starting points. First, we have suggested that there are some deep-seated human information drives. Second, we have proffered the four u-constructs as fundamental information drives. We need to have a scholarly debate on these implications. Is it reasonable to propose that there exist fundamental human information drives in the same way that there exist general human drives [Lawrence and Nohria, 2002]? If such a proposition is reasonable, then what are these drives? We maintain such questions address core issues for information systems scholars, and it is pertinent to address them. Doing so might help us to clarify our identity and provide conceptual foundations on which other fields might draw (e.g., how does the need for information unison influence organizational design?)

Each of the u-constructs spans a dimension along which information systems are currently advancing. As such, they represent the next step in digitization as *true* ubiquity, uniqueness, universality, and unison will have profound implications, including that of influencing IS theories, many of which were developed during the era of mainframe or end-user personal computing when technology was fixed in space. With an understanding of the fundamental drives of information systems, we will need to revisit some of these theories.

Because technology is undoubtedly intertwined with the task that it is designed to support, a change in the nature of information systems also constitutes a change in the nature of tasks [Goodhue and Thompson, 1995; Gopal et al., 2001; Sørensen et al., 2002]. For instance, an information system that can provide some form of any u-construct has the ability to change the nature of tasks. It not only facilitates tasks that used to be difficult to implement, but it also creates opportunities for tasks that were once non-existent or unimagined. If we understand the fundamental information needs of humans, IS scholars can be more future oriented rather than waiting to study a technology that someone else developed. We can think of a new form of IS design built around our deep understanding of humans' fundamental information needs.

For IS practitioners, as mobile penetration increases and applications become more sophisticated, the transformation of the mobile phone into a fully integrated data, communications and commerce tool seems inevitable [Kakihara and Sørensen, 2002; Sørensen, et al., 2002; Lyytinen and Yoo, 2003]. As such, the u-constructs not only provide a means to understand the potential of future "u-technologies," but also serve as an instrument for identifying consumers' needs and evaluating potential business benefits.

In the past, IS research has often been criticized for being outdated and, once researched, not relevant to industry. [Lyytinen and Yoo, 2003]. Maybe this is because IS researchers are often chasing a moving target and we have not yet identified the ultimate constructs of interest. Instead, we have been studying intermediate waypoints along. Thus, our goal was to contemplate the effects of the continuation of currently observable trends, extract the essence of these changes, and show how the u-constructs enable us to understand progress in information systems and technology. The only purpose for building an information system is to meet a human need, and only when we understand the deep structure of these needs will we build better systems.

VI. REFERENCES

EDITOR'S NOTE: The following reference list contains the address of World Wide Web pages. Readers, who have the ability to access the Web directly from their computer or are reading the paper on the Web, can gain direct access to these references. Readers are warned, however, that

1. these links existed as of the date of publication but are not guaranteed to be working thereafter.
2. the contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced.
3. the authors of the Web pages, not CAIS, are responsible for the accuracy of their content.
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