Evidence-Based Management of Information Systems: Human-Centric Approach

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ABSTRACT

Information systems are vital elements in knowledge-intensive organizations. Organizations devote significant resources to deployment and maintenance of their information infrastructure and systems. The systems incorporate resources, services and business processes critical for proper functioning of organizations. Suitable management of information systems is imperative. Despite technological advancements and significant investments, organizational information systems suffer from low usability. Low usability arises from misalignment between natural characteristics of human interactions with digital environments and their design and implementation. Analytics expose hidden difficulties and enable effective evidence-based management and innovation. We present important managerial implications of analytic findings derived from a real world case study of a large-scale organizational portal. The findings supply pertinent actionable knowledge for effective human-centric evidence-based management of information systems.

Keywords: Analytics, Usability Management, Information Systems, Actionable Knowledge Discovery.

INTRODUCTION

Information systems are among the essential assets of knowledge-intensive organizations (Davenport, 2005; Alvesson, 2004). They provide services and tools indispensable to organizations and their members. Knowledge workers rely on the services and resources the information systems provide. Distinguishing feature of information systems in organizations is the extent to which they contribute to the enhanced performance of the organization as well as its members. Well-deployed information systems foster economic benefits, while poorly deployed ones hinder performance and rise costs.

Deriving direct econometric indicators quantifying the impact of the enterprise information systems on the operating efficiency and gains is a difficult task. Due to

absence of the direct metrics, the usability analytics play the key role. The usability of information systems pertains to a spectrum of factors related to their use characteristics (Seffah et al., 2006). For instance, which services and resources are frequently used; how easy/difficult is to access and use services and resources, or execute business processes; what difficulties users usually encounter; what are the characteristics of users, etc. Examining usability allows discovering the underlying principles of the perceived efficiency of use of the organizational information systems. This directly impacts engineering, design, and development of organizational platforms and portals (Palmer, 2002).

Regardless of the recent advancements in portal systems technology and substantial investments by organizations, the usability of organizational portals has been low (Geczy et al., 2007, 2009). The provided services and resources are commonly underutilized, difficult to access, and business processes are not easily executable. The improvement of the present status has been lacking. Commercial organizations have been overly focused on the external web presence—interfacing their customers, rather than the internal web presence—benefitting their employees. The obvious objective has been a revenue generation: increasing visitor-customer conversion rates, and targeting marketing campaigns to proper groups and demographics (Moe, 2003).

Improving usability of information systems and internal web presence has a considerable potential for increasing the productivity and streamlining the workflows (Collins, 2000). To tackle the usability issues, managers of information system have followed the best practices for designing, developing, and engineering enterprise portals (Sullivan, 2004), or employed frameworks for consistent system engineering (Nikolaidou et al., 2006). These are relevant approaches. However, they are insufficient. Alleviating the usability of organizational portals requires adoption of novel user-centric approaches.

User-centric approaches deploy analytics and draw from extracted knowledge of human behavior in organizational information environments. This requires detecting and analyzing behavior of users based on the recorded human-system interactions. Relevant methods for acquiring viable interaction data should expand beyond the conservative and invasive protocol-based studies (Benbunan-Fich, 2001) and/or eye-tracking methods (Jacob and Karn, 2003). Automated non-invasive methods for data collection, such as server-side web logs and client-side scripts, are preferable. They are transparent to users and allow collection of data without disturbing the natural human interactions in web-based environments. However, the acquired data is voluminous and its analysis presents further challenges.

This study presents important usability and behavioral findings of human-web interactions extracted from web log data. The data was acquired from a real-world large-scale organizational portal. Highly skilled knowledge workers comprised the majority of users. Derived behavioral analytics expose various characteristics of human-web interactions. Extrapolated actionable knowledge provides crucial insights for information system managers. Provided analytic framework facilitates a transformation of formerly tacit-only knowledge to explicit knowledge. Explicit knowledge enables the evidence-based management approach. The identified management action domains and available constructive solutions are addressed.

ORGANIZATIONAL INFORMATION SYSTEM

The investigated organizational information system in this study is a large-scale distributed portal of The National Institute of Advanced Industrial Science and Technology. The portal is notably complex and voluminous in terms of structure, traffic, and accumulated data (Table 1). The core comprises of six servers connected to a high-speed backbone in a load-balanced configuration. Services and resources are accessible via connectivity spanning from high-speed optical to wireless. The supported platforms range from workstations to mobile devices.

Table 1. Case study information system data characteristics.

Logged Data Volume	~60 GB
Average Daily Logged Data Volume	~54 MB
Number of Servers	6
Number of Log Records	315,005,952
Number of Resources	3,015,848
Number of Services	855
Time Period	1 Year

The portal provides a spectrum of services and resources critical to the organization. The spectrum of services is engineered to facilitate business processes for management, administration and accounting, research cooperation with industry and other institutes, and resource localization. Built-in are also bulletin boards and services for professional networking in the organization. The institute has a numerous branches throughout the country. Hence, several services and resources are distributed. The visible web space exceeds 1 GB, whereas the deep web space is considerably larger; however, it is difficult to estimate due to the decentralized system architecture and continuously changing back-end data.

The primary users of the organizational information system are skilled knowledge workers. Extensive traffic on the organizational portal results in large web log data set. The traffic, however, is both human and machine generated. Thus, the data requires appropriate cleaning. The data preparation, cleaning, and other relevant processing are detailed in (Geczy et al., 2007). The data cleaning process eliminated nearly all of the machine generated traffic. Hence, the potentially remaining machine traffic is statistically insignificant and does not affect analytics.

ANALYTIC APPROACH

Behavioral analytics have been attracting extensive attention from e-commerce sphere. Analysis of human behavior in web environments have been employed not only for usability evaluations, but also utilized for capturing accurate image of a customer experience and satisfaction (Petre et al., 2006). Various motivations and trends in e-commerce and marketing have targeted modeling and predicting the cross-site user

web behavior (Park and Fader, 2004). However, further rigorous studies are necessary in order to capture the underlying behavioral insights.

Scientific inquiries into human behavioral dynamics in digital environments have been relatively recent (Dezso et al., 2006). Human web behavior has temporally distinctive features. Humans exhibit periods of rapid activity followed by longer periods of inactivity. This behavior is generally attributed to the perceptual prioritization of tasks (Barabasi, 2005). Distinctive temporal characteristics of human web behavior can be utilized for segmenting the human-web interactions and elucidating the browsing tasks of varying complexities. A successful temporal segmentation framework of human-web behavior has recently been introduced (Geczy et al., 2007). We concisely describe the relevant concepts.

The human web behavior is seemingly relatively simple. A user visits a web page displaying information and links to other resources. After perceptually processing displayed information on a page, a user makes a conscious decision to follow-up a resource—typically indicated by a hyperlink. Clicking on the hyperlink, the desired resource is displayed. Analogously, it contains hyperlinks to other resources. Hence, the underlying interaction pattern emerges: document display → click → document display → click → document display, and so forth. This is commonly called a click-stream. The click-stream sequences contain rich information about users' browsing patterns and habits.

Analysis of click-stream sequences is performed by segmenting them into smaller constituents: sessions and subsequences. A depiction of segmentation is shown in Figure 1. The sessions relate to longer interaction sequences. They are further divided into subsequences denoting various subtasks. The segmentation is made according to the temporal activity characteristics of users.
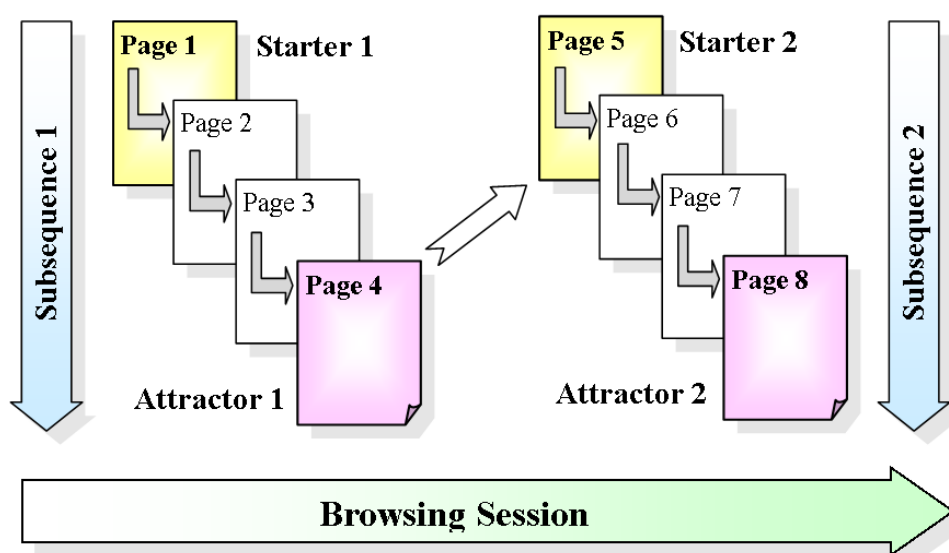

Figure 1. Illustration of segmentation of human-web interactions into sessions and subsequences together with the essential navigation points: starters and attractors.

Consider the following user activity, for instance. At the beginning of a working day, a user logins into the organizational portal (subsequence 1) and is presented with the opening page. The user then accesses the attendance service, in order to record the starting time of a working day (subsequence 2). After completing the task, the user proceeds to a calendar service—containing scheduled appointments. He/she checks the current day appointments (subsequence 3). This browsing session has three subsequences of the distinct tasks: 1–login into portal, 2–recording attendance, and 3–checking appointments.

There are two important navigation points. These are the points where users start their browsing actions–starters, and the resources they target–attractors. The starters are the first points of subsequences and/or sessions. The attractors are the last points of subsequences and/or sessions. Considering the above example of user interactions on intranet portal, the starter of the first subsequence is the login page, and the attractor is the opening portal page.

One can navigate from the same starter to the same attractor in various ways. Targeting the starter-attractor pairs allows eliminating redundancies in navigational pathways. It also exposes higher-order browsing abstractions. The starter-attractor pairs indicate the abstractions of the elemental browsing patterns. The corresponding attractor-starter pairs indicate the connecting patterns between subsequences. The elemental browsing patterns are linked together by the connecting patterns—thus forming more complex browsing and behavioral patterns. This analytic framework enables us to analyze the essential navigation points and their access characteristics together with the elemental and complex browsing patterns and their formations.

INTERACTION AND USABILITY FINDINGS

The described human-web interaction and usability analytic concept uncovers numerous hidden characteristics of portal users. Our large-scale organizational case study revealed various important findings. Selected observations highlight human-web interactions and use features of knowledge workers. They also expose problematic issues. Selected relevant findings are concisely described in the following paragraphs.

- **Underutilization**. Large number of resources and services contributed to information overload. More than three million resources are too much by most standards for any individual. Hence, large number of resources and services were underutilized. Frequently utilized resources amounted to less than 9.55%. More than half of the services have been used rarely.
- **Task Segmentation**. Conventionally, we tend to divide more complex tasks into several simpler subtasks. The same holds in portal environments. The knowledge workers divided more complex browsing and navigational tasks into approximately three subtasks.
- **Attention Span**. Extensive exposure to media has been reported to contribute to a short attention span; particularly in children and adolescents (Christakis and Zimmerman, 2006). We have also observed a short attention span in knowledge workers operating in portal environments. The average attention span was approximately 6.5 minutes.

- **Pattern Formation**. The knowledge workers exhibited significant tendency to form both elemental and complex interaction patterns. They repetitively utilize relatively small spectrum of starter-attractor and attractor-starter pairs. This implies formation of both elemental and complex browsing patterns.
- **Browsing Strategy**. Common browsing strategy of knowledge workers has been exposed. It can be concisely described as: knowing the starting point of navigation and the traversal pathway to the target. The users were more familiar with the initial points of their navigation rather than the exact location of targets.
- **Habituation**. Habituation refers to a reduction of behavioral response due to repetitive stimuli and/or prolonged exposure. Routines and repetitive processes largely contribute to habituation (McSweeney and Swindell, 2002). Extensive use of the organizational portal resulted in browsing habituation of knowledge workers. Their ranges of frequently accessed resources and services have shrunken.

Usability and human-web interaction observations expose several important characteristics. They highlight how knowledge workers interact with web portal environment, and which resources and services they use frequently and efficiently. Importantly, the findings also highlight problematic issues. They uncover underutilized services and resources, as well as other problematic aspects requiring attention and corrections. The findings provide actionable knowledge for usability management of organizational information systems.

EVIDENCE-BASED HUMAN-CENTRIC MANAGEMENT

Traditional management of information systems has been extensively relying on tacit knowledge. Managers have been pursuing and accumulating tacit knowledge over the numerous years. Transfer of tacit knowledge and/or its conversion to implicit or explicit forms have been faced with extensive difficulties. Modern information technologies and analytics have a potential to provide solutions for making tacit knowledge tangible without becoming explicit. Thus, organizations could leverage the tangibility of tacitly expressed entities (Stenmark, 2001).

Analytics open up a new dimension of management style: the evidence-based management. Analytically obtained evidence can eliminate the guesswork in critical decision-making. Highly or poorly performing system elements and services can be directly identified and assessed. Analytically obtained knowledge transforms significant portion of formerly tacit knowledge into explicit form. It substantially lowers the uncertainty level in the decision-making process and facilitates the evidence-based management. The evidence-based management is a progressive step in information systems management (Hamel, 2007).

Behavioral characteristics and usability findings of knowledge workers on the case study large-scale organizational portal expose pertinent actionable knowledge. The implications extend to several managerial domains. The high-priority action domains are addressed in the following paragraphs.

Deployment of Analytics

"The overwhelming majority of organizations, however, have neither a finely honed analytical capability nor a detailed plan to develop one." (Davenport and Harris, 2007) Lack of analytical capabilities in organizations limits their management efficiency. System analytics are vital for detecting and identifying the strengths and weaknesses. Unfortunately, organizations conventionally employ analytic approaches only in limited areas; such as hardware, bandwidth, and security concerns (Kamoun, 2005). The analytics should be deployed into spheres of usability monitoring and behavioral user analysis.

The usability observations uncover how users utilize the organizational portals and information systems. Some resources and services may be used efficiently, whereas the others inadequately. The presented case study revealed a significant underutilization. The analytics and usability assessments can pinpoint which resources and service have high usability and which low. The critical business processes and services with low usability obstruct operating efficiency of organizations. Knowing which critical processes have usability deficiencies enables accurate targeting of improvement efforts. On the other hand, the non-critical low usability processes and resources may be eliminated, in order to decrease information overload.

Engineering User-Centric Processes

Knowledge-intensive organizations are increasingly transferring both critical and non-critical business processes to their information systems. This brings numerous benefits. It facilitates automation, monitoring, archiving, and many other aspects (Jeston and Nelis, 2008). Numerous business processes deployed on the organizational portals require human involvements and interactions. Characteristics of human interactions are commonly unaccounted for during the engineering and design. Unsuitably designed business processes reduce working efficiency and bring on negative experiences.

Business process design and engineering should be aligned with the essential usability characteristics and human interactions. Regrettably, many implementations of business processes often result in multistage and extended human-system interactions. The extensive multistage division may seem logical from the perspective of business requirements. However, it may be misaligned with the natural human tendency to segment tasks in digital environments.

The analytic observations indicate that the knowledge workers divide their more complex interaction tasks into three subtasks on average. This suggests that the extensive multistage business processes should be reengineered and redesigned, in order to accommodate the natural human task division characteristics. Furthermore, each subtask should require less than approximately seven minutes of attention—when accounting for the observed short attention span.

Important features may be neglected or underestimated even despite the best engineering and design efforts. The user engagement and feedback are essential in such cases. They should be utilized as early as possible. It is advisable to engage the target users constructively from the early stages of process life cycle, so as to avoid

costly later-stage adjustments. Active feedback and verification mechanisms are important for continuous improvement and innovation.

Delivering Personalization

Working, interacting and browsing styles differ among knowledge workers. Information systems and portals should accommodate the individuality of knowledge workers. Analogously, there are interaction similarities among groups of users. These should also be taken into account.

Traditionally, the interface design and interaction schemes of organizational portals and other information systems have relied on one-fit-all style. Adjustments in interface and/or functionality have been approached by implementing few options. Such system design and interface engineering are inadequate to capture individuality of knowledge workers or groups. This leads to negative interaction experience resulting in underutilization.

It is pertinent to approach the human-system interactivity in a personalized manner (Baraglia and Silvestri, 2007). Two essential levels of personalization should be considered: individual and group. The group–level personalization tackles the adjustments of interface and system functionality for a set of users having similar behavioral, interacting and working characteristics. For example, a group of employees in administrative divisions generally perform routine tasks on organizational portals. Although individual group members are unique, they work in a team environment and perform as a team. The team may internally standardize their work routines. This improves team uniformity, allows group-style workload processing, and eases member substitution. Hence, the group-level personalization is preferable in this case. The individual–level personalization facilitates personalized interfaces and functionality for individual users. The individual–level personalization is desirable for creative and knowledge work; for example, in the research and development. Researchers, scientists and developers display unique working styles and habits. They may significantly benefit from the individual-level personalization.

Personalization is directly related to profiling (Nasraoui et al., 2008). Well-formed profiles of individual knowledge workers and groups should envelop important behavioral and interaction characteristics. Personalization features and interface adjustments should be based on the profile characteristics. Users with similar behavioral and interaction characteristic can be clustered automatically, or groups may employ manual methods for group selections and adjustments. Interaction and behavioral characteristics change over time. Profiles and personalization features should dynamically reflect such changes. The changes are detectable by the analytic methods. Thus, it is pertinent that analytics are deployed permanently.

CONCLUSIONS

The work presented the key aspects of the user-centric and evidence-based management of organizational portals and information systems. Extensive analytic evidence derived from a case study of a large-scale organizational portal of knowledge-intensive organization is a base for introduced actionable knowledge.

Analytic framework enables detailed elucidation of interactions, behavioral and usability aspects. The framework utilizes temporal segmentation of human-web interactions. It identifies essential navigation features as well as elemental and complex browsing patterns. The essential navigational points are those where users start and end their interactions. The pairs of starting and ending elements underline higher order abstractions. They are formed from the elemental navigational patterns. The users form both elemental and complex patterns.

Analytic findings revealed imperative behavioral and usability characteristics. Significant underutilization of services and resources has been observed. Less than ten percent of resources have been efficiently used. The knowledge workers divide their more complex interactions to simpler subtasks. Longer browsing sessions have been split into three subsequences on average. A significantly short attention span has been observed. The knowledge workers have exhibited average attention span of less than 7 minutes. Browsing and interaction habituation takes place as users become more familiar with the portal environment. Their interactions habituate into frequent patterns and rapid transitions. Additional effect of habituation is a lack of exploratory behavior.

Analytic observations translate to actionable knowledge for managers of information systems. Effective deployment of suitable interaction and system analytics is a precursor for the evidence-based management. The analytics provide vital information for decision-making. Availability of direct analytic evidence decreases the level of uncertainty for proper decision-making. Thus, the information technology managers gain better and sharper perspective on the underlying usability issues. It enables them to make more informed decisions. The efficient management of organizational portals requires an alignment of the engineering, design and implementation with the behavioral and usability characteristics of users. The user-centric approach demands proactively addressing these high priority domains: deploying analytics, suitable engineering of process, and providing multi-level personalization. These critical management domains should effectively utilize available analytics. Knowledge transformation and generation are the essential mechanisms facilitating uninterrupted improvement and innovation of organizational information systems.

ACKNOWLEDGEMENTS

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