Unstructured Interaction: Integrating informal handwritten knowledge into Business Processes

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Abstract

Business processes are a widespread approach to managing and planning organizational activities. However, human work practices often differ from structured, formal process descriptions. Knowledge on process variations therefore becomes a key aspect in enacting and controlling business processes. Such knowledge usually is informally documented. Traditional paper, carrying handwritten information, still serves as one of the prevalent media in this context. Even in computer supported work environments, paper based documents are still common in professional settings. As a solution to the problem of integrating handwritten, informally specified knowledge into business processes, the concept of *unstructured interaction* is introduced and elaborated.

1 Introduction

Contemporary Business Process Management (BPM) solutions rely upon formal process models. On the one hand, formal process models alleviate the mapping from process to information technology, thereby providing a huge potential for efficiency gains. On the other hand, they impose severe constraints for human actors involved in the process. In reality, people tend to vary the routines, make concessions and negotiate informally. These work practices should actively be supported by business process management solutions [18]. Current systems, however, offer no satisfactory support for such practices.

People document knowledge on process variations in an unstructured, informal way, e.g. as notes, post-its or sketches. Paper in general and handwritten documents in particular – in computer supported work environments complemented by electronic notes, memos and even emails – are still common in this context, due to their flexibility and ease-of-use [14].

Looking at business processes and the role a human actor plays in these processes from an organizational perspective, allows for easier management of an organization's processes. In reality, however, a single person is simultaneously involved in various processes, she even plays several roles in a single process. This requires a new modeling perspective, focusing on the individual involvement in processes [5].

As a result, knowledge documented by individuals is subject to the very same conditions: A post-it on an employee's desktop could convey information on any of the current processes this employee is involved in. Information might be spread on several separate locations and media, jointly representing knowledge relevant to a single business process, or a combination of the processes a person is involved in.

This leads to the question: How could the process management solution benefit from the informally specified, heterogeneously documented knowledge acquired during the process of regular human work?

As solution, the concept of *unstructured interaction* is introduced. Conveying information to contribute knowledge to a business process is regarded here as a form of *interaction* with the process itself. There are no constraints on the contents, form or location of information, so it is *unstructured* in its nature. This *unstructured interaction* can be decoupled from the current state of the process and the medium used to interact with and subsequently be re-integrated into the process, using process and user context models combined with a semantic analysis of the contents of information. It is therefore also *unstructured* regarding to the structured process.

2 Scenario

To illustrate the concept of unstructured interaction in business processes, consider the example of Sally and Tom. Tom is an employee working as floor man in a large grocery store. Sally is a customer in the very same store. From the perspective of the store keeper, both participate in the business process of selling goods. Sally in the role of an external actor (customer) and Tom as an internal actor (employee).

Sally is a working mother of three children, she has only limited time resources for grocery shopping and needs to plan her tours. As a result, Sally relies on a handwritten grocery list to organize her shopping. She tried organizing these shopping tours on her smart phone, but eventually fell back to the handwritten list which allows for easier and more natural planning. Today, Sally enters her favorite store and discovers an information sign telling her of a new digital grocery shopping assistant offered by the store.

Curious, Sally reads more information about the program. It turns out that the store offers an application Sally might load on her smart phone, capable of aiding Sally's shopping tour by revealing the location of goods and doing some approximate pricing calculation for her. This all will be performed based on her grocery list. In turn, the store requires the permission to evaluate Sally's anonymized shopping behavior and her grocery list. The only requirement for participation is the possession of a smart phone and a digital pen. Luckily Sally has both.

She decides to use the added value application offered by the store. To communicate this, she confirms it on her smartphone. As Sally already wrote her grocery list using her digital pen, she can start using the new application immediately. Behind the scenes, the data on Sally's digital pen (her grocery list) is transferred to the smartphone. She simply starts shopping as usual.

Meanwhile, Tom started filling the store's racks with items. When he went to the storage room to refill the milk stock in the store, he discovered that the milk had accidentally been delivered after the best-before date had expired. The pallet actually showed a different best-before date than the individual cardboards. Tom decides to leave the milk in the storage room, as it cannot be sold anyway. He marks the damage on the checklist form he uses to track his work when filling the stores racks. The checklist, has no special rubric called "damages" or even "comments". So Tom crosses out the milk, and writes a short note besides it ("Milk tainted").

While Tom was busy in the storage room, Sally continued her shopping tour in the store. Eventually she approaches the rack supposed to contain the milk. Sally notes that there is no milk left on the rack, although she intended to buy some and therefore wrote it on her grocery list. So Sally notes the missing milk on her grocery list with a small cross-sign, differentiating it from the other items she found.

At this point, Sally returns home as an unsatisfied customer, while Tom proceeds with filling the racks in the store. Eventually, after Tom finished his tour, he reports the situation to the store manager. The store manager files a complaint for the damage and orders another milk pallet. This pallet is delivered the next morning, because of the evening delivery truck just having left its station.

If the handwritten annotations could have been processed as unstructured interaction, the business process management system would have been able to react more quickly. Tom's annotations would have been processed immediately and forwarded directly to the store manager. She would have been able to order the new delivery for the same evening. Sally's intelligent shopping assistant could acquire the information of Sally's desire for milk, which is currently unsatisfiable. So it could present her with alternative suggestions through her smart phone, for example directions to the next store, or the time milk will be available again in this particular store.

3 Related Work

Related work essentially falls into either of the following three categories: Business Process Management in general, the role paper documents play in current business processes and pen and paper based interaction between a person and a digital system.

3.1 Business Process Management

In the 1990's, the concept of business processes began to appear in literature and research [20] to describe and manage organizational activities or even construct complete business-process-centric organizations. Although no common agreement on the definition of the term *Business Process* exists due to different possible levels of abstraction, empirical studies indicate that the understanding of business process in industry involves three perspectives: i) structured processes allowing for easier management, ii) methodologies to achieve business goals and iii) sociotechnical constructs with a focus on human interactions and re-

lationships [20]. As a result of their aforementioned studies, Vergidis, Turner and Tiwari point out that a strong preference towards the first perspective exists amongst queried companies.

A widely accepted definition of *Business Process Management* (BPM) has been provided by van der Aalst, Hofstede and Weske. They defined it as

> *Supporting business processes using methods, techniques and software to design, enact, control and analyze operational processes involving humans, organizations, applications, documents and other sources of information* [19]

Based on this definition they described a business process management system as a software system driven by explicit process designs serving to enact and manage operational business processes [19].

A common problem that business process management systems have to deal with, are variations. People do not always follow structured routines, they tend to vary such routines when encountering exceptional conditions. However, tracking or even managing variations in a business process management system proves to be challenging. Recent approaches therefore focus on bottom-up concepts, shifting the focus from the organizational to the individual perspective of users (e.g. [18], [12]).

An individual perspective allows for taking the interaction between persons and business processes into account. Genovese, Comport and Hayward described the changes of processes based on the actions of process actors as person to process interaction [5] and emphasized the need for such concepts in BPM systems. Their informal definition of person to process interaction served as basis for the view taken in the presented approach.

3.2 Paper as Medium in Business Processes

Writing on paper essentially serves conveying information, either focused on temporal (e.g. documentation), spatial (e.g. writing a letter) or social (e.g. communication, collaboration) aspects. With traditional paper still being a prevalent medium in business processes [14], conveying written information is an essential part of current work practices. Professionals, especially knowledge workers, tend to use handwriting for informal note taking [4].

Traditional paper affordances are numerous. Paper provides a very robust, flexible, mobile and cheap medium compared to most digital systems [14], allowing instantaneous interaction without annoying start-up times [21]. However, digital systems offer also clear advantages when it comes to information management, hyperlinking, communication etc. least to speak of processing and computation capabilities. Integrating both worlds, bridging the gap between the physical information documented on traditional paper and the information stored and managed in digital systems, has been the goal of many approaches (e.g. [21], [17], [6], [10]).

3.3 Pen and Paper Based Interaction

Pen and paper based interaction (PPI) describes a form of interaction between a user and a digital system using paper and a *digital pen* as input media. A digital pen essentially is an ordinary pen capable of tracking its movements either in relation to other media (e.g. paper or a display device) or in an absolute fashion. Whether a user actual inks the document, i.e. physically alters the structure of paper by

letting ink colorize certain locations, depends on the type of interaction. Gesturing on paper without inking also falls in the category of PPI. An empirically validated set of basic interactions between users and digital systems through usage of paper and digital pens can be found in [17]. Additionally, a set of potential usage scenarios for pen and paper based interaction techniques is described in [4].

The Anoto Pen

Digital pens facilitate pen and paper based interaction. A prominent example for such a digital pen is the Anoto pen [1]. It is employed in most current PPI based user interfaces ([21], [17], [6], [10], [16]). To track pen movements, this technology relies on a proprietary dot-pattern. The pattern is printed onto traditional paper. A camera built into the Anoto pen scans the page for this dot pattern. Based on the scanned dots, the absolute position of the pen on paper can be determined. It is even possible to uniquely identify the page the pen is moving on.

Anoto based interaction allows more than conveying information on paper through inking, which then is transferred into a digital system. Gesture systems have been built to allow control of digital functionality thus narrowing the gap between the physical and digital world even further (e.g. [8], [17]). However, a problem special to pen and paper based interaction is the feedback channel. While the pen itself potentially leaves physical marks on paper by inking it, providing digital feedback requires additional concepts. To compensate this, Liao, Guimbretière and Loeckenhoff designed a prototypical extension to the digital pen, which is capable to provide visual, acoustic and haptic feedback [9]. Newer digital pens also employ similar feedback mechanisms [13].

3.4 Summary

If a business process management system supports pen and paper based interaction, information conveyed on paper could be integrated into the process using *unstructured interaction*. Beaudouin-Lafon described two essential levels for analysis and design of interaction between a digital system and a person [3]. *Interaction paradigms* provide a user centered high-level conception of the phenomenon of interaction, while *interaction models* offer operational descriptions of the course of interaction. Interaction models, such as for example *instrumental interaction* [2] or *direct manipulation* [15], provide guidelines for interaction design.

Reality based interaction provides a conceptual framework on a higher layer of abstraction [7], a specialized view on interaction between people and digital systems designed to conceptualize evolving interaction techniques. However, none of these approaches is suitable to describe the concept of unstructured interaction as presented in this paper.

4 Unstructured Interaction

Unstructured interaction essentially provides a different view on the course of interaction than traditional approaches. It differs mainly by not assuming that there is an underlying structure for interaction, a common language both interacting entities are required to understand completely. Instead it assumes that one entity acts and the other entity reacts based on its interpretation of this action. In the following, this concept is elaborated on with the goal to derive a definition of unstructured interaction by discrimination.

4.1 Structured Interaction

Interaction describes a phenomenon where the actions of two entities mutually affect each other. In case of interaction between a person, referred to as the *user*, and a digital system, the actions of the user affect the internal state of the digital system, while the perceived system state affects the actions of the user. The hardware and software components allowing the user to interact with the digital system are commonly referred to as the *user interface* (UI).

Traditional UIs, such as the widely known graphical user interfaces (GUI) predominantly employed in today's computer systems, restrict the possible way's of interaction. Only a limited set of control actions is supported and their affordances are exposed by the system. The UI thus ideally provides a set of necessary and sufficient actions to control the system, a control language the user needs to understand. In the following, interaction based on such a concept is referred to as *Structured Interaction*. An example for UIs based on structured interaction are today's (still) predominant WIMP interfaces (Window, Icon, Menu, Pointer).

A drawback of such an approach is that only those actions the UI designers considered are supported. Furthermore, mechanisms to distinguish valid actions from invalid ones are needed. Designers need to pay attention that the affordances communicated by the system and controls possible through its UI match (c.f. Norman's *Gulf of Execution*[11]) and that no illegal states are possible.

4.2 Unstructured Interaction

Unstructured Interaction takes an alternative approach towards the problem. No structuring of the interface by active restriction is presumed. Users might express their intentions only limited by the physical constraints of the user interface: the system strives to understand the actions of the user and interprets them. UIs based on natural language processing provide an example for user interfaces of this category. The problems for the designer shift form restriction and affordance control, to understanding. This leads to our definition of unstructured interaction:

> *Unstructured interaction describes interaction which is not based on the underlying structure of a formal language completely understood by interacting entities. Interacting entities strive to understand each other by interpretation, resembling the informal form of human communication.*

Following Beaudouin-Lafon's approach to analyze the phenomenon of human computer interaction [3], the principle of unstructured interaction encourages the *computer-as-partner* interaction paradigm. In such an interaction paradigm, the user delegates tasks to the computer. However, UIs designed to support unstructured interaction might also be employed in systems supporting different interactions paradigms (i.e. *computer-as-tool*, *computer-as-medium*).

4.3 Unstructured Interaction in Business Processes

Bringing information conveyed on physical documents into intelligent business processes essentially forms an interaction between a person and a process. The person, with respect to the process here referred to as *actor*, conveys some information relevant to the process. The process reacts to
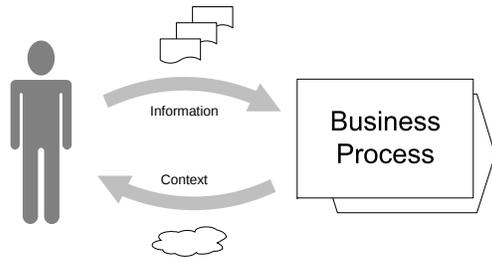
Figure 1: Interaction between persons and business processes

this information, meaning that its further flow of execution depends on the information. This in turn affects the actor by changing her context, as she is playing a role in the process. Consequently, the actions of two entities mutually affect each other, as shown in Figure 1 and we can speak of *interaction*. Following the terminology introduced in [5], such interaction is here referred to as *person to process interaction*. BPM systems designed to support intelligent business processes have also to provide support for person to process interaction: an appropriate user interface is needed.

Using structured interaction in person to process interaction means that the information conveyed needs to be formalized. However, formalization contradicts the informal way information is gathered and documented throughout the process of work and results in loosing part of the information. Only those interactions the system designer considered beforehand are allowed, which is by definition not the case under exceptional conditions.

Person to process interaction based on the concept of unstructured interaction contributes to the solution of such problems. User actions are interpreted by the system. It analyzes information obtained from user actions, generates knowledge on the current situation and re-integrates this knowledge into the managed process. Although the system itself is unable to process information it cannot understand, the borders which information potentially could be included at which point in time would become softer.

4.4 Pen and Paper based Interaction (PPI) in Business Processes

The absence of a formal structuring for the contents of blank paper ("what" can be written on it) serves the need to convey *any* desired information. For example, engineers might convey information consisting of a mixture of mathematical formulae, technical drawings and written sentences to document a specific design idea. A text entry field on their computer or smartphone simply does not allow to do so, unlike an empty sheet of paper.

Recent studies corroborate this. Chapman, Lahav and Burgess report in their field study on handwritten documentation practices in enterprises a free mix of text, drawings, mathematical symbols and drug or term abbreviations, and a distribution of information on many, sometimes casual, paper artifacts [4].

Paper is commonly used in current work practices [14]. A lot of information important to business processes resides on paper artifacts. Thus it cannot be accessed by the business process management systems employed. Information conveyed on paper artifacts is heterogeneously documented, informal and unstructured. Hence it can be concluded that pen and paper based interaction between a

person and process needs a user interface based on an unstructured interaction concept, rather than limiting the potential by artificially structuring the interaction. The system needs to understand as much as possible of the information conveyed by the user, without the guarantee to understand the complete information.

5 Support of Unstructured Interaction in Business Processes

Granted that interfaces based on the concept of unstructured interaction contribute to the solution of integrating knowledge in business processes, the question remains how to realize such interfaces. How would actual system support be realized? How could the sheer complexity of informally specified information be handled?

The central idea to reduce complexity is to take the context of interaction into account. Formal process descriptions of business processes being executed provide such structured context. It can be assumed, that the current tasks an individual person is involved in are available. Based on these individual tasks, the interaction itself can be interpreted and related to the ongoing activities. So the formal process description provides a structural framework for informal information.

5.1 The Interaction Processing Pipeline

As shown in section 4.4, pen and paper based interaction (PPI) provides an example of unstructured interaction in the domain of business processes. Figure 2 displays the relevant aspects of unstructured interaction support for pen and paper based interaction. As you can see, realizing unstructured PPI involves the following steps

(i) Process

(ii) Understand

(iii) Integrate

Processing describes the conversion of raw inking or gesture data to meaningful constructs. Samples of pen positions are transformed into strokes and gestures. Strokes and pen movements on a document are segmented into areas containing drawings, written information, formulae etc. Knowledge on the process context could already be used at
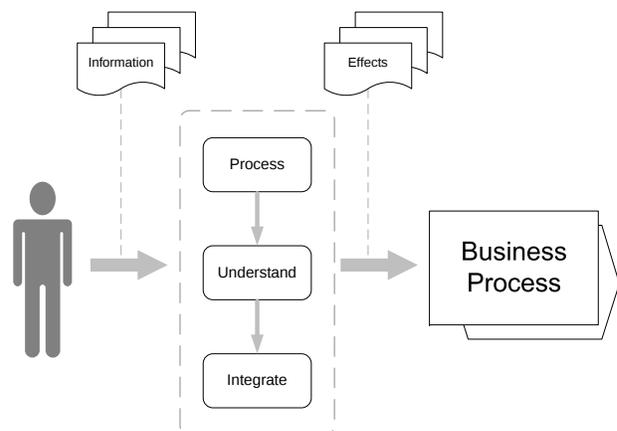

Figure 2: The interaction processing pipeline for pen and paper based interaction in business processes

the processing stage to identify written objects. For example, if a sales agent inks a note while she discusses something with a client on the phone, the information might more likely be text than formulae.

Understanding takes the processed information and interprets it. Information is placed in the context of current processes and a semantic model of this information and its relation to a current process is derived. Then the appropriate processes to which this information might be relevant are identified. Naturally, this step also relies on the current process context.

Integrate finally uses the semantic information model and the process context to integrate the information into the process. The general process model and its currently running instance are analyzed and the optimal type of integration is determined. Such integration might for example be choosing an alternative flow, firing a process event or altering a process artifact (i.e. a document).

A business process management system supporting unstructured PPI will have to address these issues. It needs to employ an information or rather interaction processing pipeline and adequate business process context models.

5.2   User Based Perspective

It has been shown, that a user centric perspective in business process management based on the work of individuals involved in process provides several benefits [18], [12], [5]. Following a user centric approach to realize person to process interaction based on the concept of unstructured interaction therefore requires the business process management system to take the multiple roles a user might play in several business processes into account. The motivation and rationale behind user participation in the business process is another relevant aspect contributing to context information.

Essentially, users, or to be precise *actors*, in business processes could be grouped based on their motivation or goals into

(i) internal actors

(ii) external actors

Internal actors are entities carrying out work activities with the goal to advance the business process. Incremental advancement ultimately results in the completion of a business process. In typical constellations such actors are employees or systems of the organization executing the business process, although exceptions are thinkable. Goals of internal actors are related to the goals of the business process as a whole generally speaking. On the contrary, *External actors* are entities carrying out activities based on goals unrelated to the goals of the business process. Such actors are in most cases customers or external systems.

Interaction between the process and a user depends on the role this user assumes. Consider internal actors, which contribute to the advancement of a business process intentionally. Therefore the state of a current process instance provides a strong indicator for processing of information written by internal actors.

External actors might also convey written information. In their case, the state of an organizations business processes does not necessarily provide an indicator for the context of written information. However, compared to information conveyed by internal actors, their information might not be as relevant regarding the business process.

Based on the user role, two complementary use cases for unstructured pen and paper based interaction in business processes can be identified. They are illustrated in the scenario in section 2. Although this selection of use cases is far from complete, it illustrates usage of the same concept in two complementary applications.

The first use case shows how internal actors annotate documents with information relevant to the process (c.f. Tom and the comments he made). The second use case describes integrating informally specified information from external sources (c.f. Sally and the grocery list). Both are merged into a single scenario, to illustrate the interconnection between informations and several simultaneously executed processes (c.f. the supermarket's process and Sally's personal shopping process).

6   Conclusion and Research Perspective

The contributions of this paper are twofold. First, the concept of *unstructured interaction* was defined and elaborated. Its importance and applicability in integrating handwritten information into business processes was highlighted. Second, an initial guideline for the design of business process management solutions based on such an interaction concept has been proposed. Relevant processing stages for handwritten information in business processes have been pointed out. Such processing bases upon the structural framework provided by a formal process description employed in the business process management system.

The key questions for further research on the subject are oriented on the three aspects introduced in section 5. i) Concepts to process and model information conveyed on paper are needed. Even at this early stage the role of the process context and its potential impact has to be researched. ii) The question how to understand such information in the process context needs to be addressed. iii) An adequate approach to integrate this information into the business process will be needed.

References

[1] Anoto. Digital pen and paper technology. http://www.anoto.com/.

[2] Michel Beaudouin-Lafon. Instrumental interaction: an interaction model for designing post-wimp user interfaces. In *CHI '00: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 446–453, New York, NY, USA, 2000. ACM.

[3] Michel Beaudouin-Lafon. Designing interaction, not interfaces. In *AVI '04: Proceedings of the working conference on Advanced visual interfaces*, pages 15–22, New York, NY, USA, 2004. ACM.

[4] C.N. Chapman, M. Lahav, and S. Burgess. Digital pen: Four rounds of ethnographic and field research. In *Proceedings of the 42nd Hawaii International Conference on System Sciences, HICSS '09*, pages 1–10, Jan. 2009.

[5] Yvonne Genovese, Jeff Comport, and Simon Hayward. Person-to-process interaction emerges as the 'process of me'. Gartner Research, May 2006.

[6] François Guimbretière. Paper augmented digital documents. In *UIST '03: Proceedings of the 16th annual ACM symposium on User interface software and technology*, pages 51–60, New York, NY, USA, 2003. ACM.

[7] Robert J.K. Jacob, Audrey Girouard, Leanne M. Hirshfield, Michael S. Horn, Orit Shaer, Erin Treacy Solovey, and Jamie Zigelbaum. Reality-based interaction: a framework for post-wimp interfaces. In *CHI '08: Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems*, pages 201–210, New York, NY, USA, 2008. ACM.

[8] Chunyuan Liao, François Guimbretière, Ken Hinckley, and Jim Hollan. Papiercraft: A gesture-based command system for interactive paper. *ACM Trans. Comput.-Hum. Interact.*, 14(4):1–27, 2008.

[9] Chunyuan Liao, François Guimbretière, and Corinna E. Loeckenhoff. Pen-top feedback for paper-based interfaces. In *UIST '06: Proceedings of the 19th annual ACM symposium on User interface software and technology*, pages 201–210, New York, NY, USA, 2006. ACM.

[10] Wendy E. Mackay, Guillaume Pothier, Catherine Letondal, Kaare Bøegh, and Hans Erik Sørensen. The missing link: augmenting biology laboratory notebooks. In *UIST '02: Proceedings of the 15th annual ACM symposium on User interface software and technology*, pages 41–50, New York, NY, USA, 2002. ACM.

[11] Donald A. Norman. *The design of everyday things*. Basic Books, [New York], 1. basic paperback ed., [nachdr.] edition, 2002.

[12] U.V. Riss, A. Rickayzen, H. Maus, and W.M. van der Aalst. Challenges for business process and task management. *Journal of Universal Knowledge Management*, 0(2):77–100, 2005.

[13] K. Schreiner. Uniting the paper and digital worlds. *Computer Graphics and Applications, IEEE*, 28(6):6–10, Nov.-Dec. 2008.

[14] Abigail J. Sellen and Richard H. R. Harper. *The Myth of the Paperless Office*. MIT Press, Cambridge, MA, USA, 2003.

[15] B. Shneiderman. Direct manipulation: A step beyond programming languages. *Computer*, 16(8):57–69, Aug. 1983.

[16] Beat Signer and Moira C. Norrie. Paperpoint: a paper-based presentation and interactive paper prototyping tool. In *TEI '07: Proceedings of the 1st international conference on Tangible and embedded interaction*, pages 57–64, New York, NY, USA, 2007. ACM.

[17] Jürgen Steimle. Designing pen-and-paper user interfaces for interaction with documents. In *TEI '09: Proceedings of the 3rd International Conference on Tangible and Embedded Interaction*, pages 197–204, New York, NY, USA, 2009. ACM.

[18] Todor Stoitsev, Stefan Scheidl, and Michael Spahn. Task models and diagrams for user interface design. In *Task Models and Diagrams for User Interface Design*, volume 4849 of *Lecture Notes in Computer Science*, pages 213 – 226, 2007.

[19] Wil van der Aalst, Arthur ter Hofstede, and Mathias Weske. Business process management: A survey. In *Business Process Management*, volume 2678/2003 of *Lecture Notes in Computer Science*, pages 1019–1019. Springer Berlin / Heidelberg, 2003.

[20] K. Vergidis, C.J. Turner, and A. Tiwari. Business process perspectives: Theoretical developments vs. real-world practice. *International Journal of Production Economics*, 114(1):91 – 104, 2008. Special Section on Competitive Advantage through Global Supply Chains.

[21] Ron Yeh, Chunyuan Liao, Scott Klemmer, François Guimbretière, Brian Lee, Boyko Kakaradov, Jeannie Stamberger, and Andreas Paepcke. Butterflynet: a mobile capture and access system for field biology research. In *CHI '06: Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 571–580, New York, NY, USA, 2006. ACM.