Information Systems for "Wicked Problems"

Research at the Intersection of Social Media and Collective Intelligence

The objective of this commentary is to propose fruitful research directions built upon the reciprocal interplay of social media and collective intelligence. We focus on "wicked problems" – a class of problems that Introne et al. (2013) call "problems for which no single computational formulation of the problem is sufficient, for which different stakeholders do not even agree on what the problem really is, and for which there are no right or wrong answers, only answers that are better or worse from different points of view". We argue that information systems research in particular can help to design appropriate systems due to benefits derived from the combined perspectives of both social media and collective intelligence.

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1 Relevance and Timeliness of the Topic for Business and Information Systems Engineering

Wicked problems (e.g., Churchman 1967, pp. B141–B142; Rittel and Weber 1973, pp. 155–169) are "problems for which no single computational formulation of the problem is sufficient, for which different stakeholders do not even agree on what the problem really is, and for which there are no right or wrong answers, only answers that are better or worse from different points of view" (Introne et al. 2013, p. 45). Many problems in management – including strategic decision-making, product design, and so on – are wicked in this sense, as are (unfortunately) most social and political problems, including "grand challenges" related to environment, health care, social welfare, education, and security (European Commission 2009; nA 2009; Mertens and Barbian 2013). We argue that there is a significant lack of appropriate information systems (and functionality) that contribute to addressing wicked problems successfully. More specifically and as an example, we may envision large-scale and function-rich information systems that support thousands if not hundreds of thousands of knowledge workers working simultaneously to solve wicked problems in close, cross-organizational collaboration. In a business context, IBM's Jam concept may serve as an early example of such a kind of information system (compare Bjelland and Wood 2008, p. 32). However, our envisioned large-scale information systems surpass the IBM system in their functionalities. The rich body of widely ranging social computing technologies that has emerged in the past few decades, is the informative basis for this quest; it includes (compare Klein 2012, pp. 449–473) email, chat, Web forums, wikis (e.g., Wikipedia), media sharing, open source software development efforts (e.g., Linux), solution competitions (such as Innocentive.com), idea-sharing systems (e.g., ideastorm.com), peer-filtering sites (e.g., Slashdot), group decision support systems (GDSS), and scientific collaboratories (Finholt 2002, pp. 73–107).

The central claim put forward in this research commentary is that research conducted at the crossroads of collective intelligence and social media can help us design appropriate information systems for wicked problems. The confidence that this claim can be met comes from recent advances in collective intelligence facilitated by the high level of participation of millions of people in social media environments.

"Social media" and "collective intelligence" have become research catchwords (see, e.g., Leimeister 2010, pp. 245–248). A search for "collective intelligence" in Thomson Reuters' Web of Science in the title, keywords, and abstracts fields resulted in 607 hits (July 1st 2013), and a similar search for "social media" resulted in 2,796 hits. Results from Google Ngram show the degree to which references to these two terms have increased in books in recent years and – notably – as far back as the early 1900s and the 1920–1950s (http://books.google.com/ngrams/graph). Further, there have also been special issues of academic journals devoted to collective intelligence (e.g., Kapetanios and Koutrika 2010, pp. 1–3) and social media (e.g., Boll et al. 2011; Chen and Yang 2011, pp. 826–827; Cortizo et al. 2011, pp. 5–7; Hiltz et al. 2011; Liang and Turban 2011, pp. 5–13; Schoder et al. 2013a, 2013b, pp. 9–15).

The proposed research also contributes to the longstanding academic discourse regarding the challenge of how to increase knowledge worker productivity. There have been repeated calls for advancing knowledge worker productivity over the years (Davenport et al. 1998, pp. 43–57; Davenport and Prusak 1998; Alavi and Leidner 2001, pp. 107–136). In information systems (IS) research in particular, we have examined how information systems can support knowledge workers in their knowledge creation, storage/retrieval, transfer, and application (see Alavi and Leidner, pp. 107–136 for a detailed discussion of each of these points). However, in the past we limited our studies to knowledge management within a firm. We have seldom analyzed how knowledge operates in large-scale information systems that cross organizational boundaries (such as social media), and how collective intelligence emerges or could be fostered.

2 Problem Description and Research Challenges

Before describing the research problem and highlighting the research challenges, it is important to define the terms social media and collective intelligence. As a minimal consensus, "social media" is used as a generic term for social interactions built on a multitude of digital media and technologies that allow users to create and share content and act collaboratively (Schoder et al. 2013a, pp. 9–15).[1] Prominent examples of companies offering these types of services include online social networking platforms such as Facebook, LinkedIn, and Google+; microblogging sites such as Twitter, Sina Weibo, and Tumblr; and platforms for exchanging visual media such as YouTube and Flickr.

While there are more than 500 published papers on collective intelligence (CI), research has not yet converged on a common definition. While some can help us find a definition for "collective intelligence", many use the term "collective intelligence" to refer to different phenomena. For example, Woolley et al. (2010, p. 687) define CI as "the general ability of the group to perform a variety of tasks. Empirically, collective intelligence is the inference one draws when the ability of a group to perform one task is correlated with that group's ability to perform a wide range of other tasks." Vanderhaeghen et al. (2010, p. 17) define CI as "the fact that the locally controlled behavior of a number of individuals leads to successful problem solving". Gregg (2009, p. 456) defines CI as "intelligence that emerges from the collaboration and competition of many individuals". Hiltz et al. (1991, p. 92) define CI as "the ability of a group to arrive at a solution that is better than any of the members achieved individually". Leimeister (2010, pp. 245–248) deconstructs "collective intelligence" etymologically and concludes with a definition of collective intelligence from the MIT Center for Collective Intelligence, that is, "groups of individuals doing things collectively that seem intelligent". Finally, Luo and colleagues (2009, p. 204) define collective intelligence of human groups as "the idea that a human group may manifest higher capabilities of information-processing and problem-

solving than any individual participant of that group does, especially when the participants densely interact with each other through the computerized communication channels such as the Internet and the World Wide Web".

Many IS researchers (e.g., Kapetanios and Koutrika 2010, p. 1; Leimeister 2010, p. 246) quote the main question of collective intelligence research that was formulated by a research group led by Tom Malone at the Massachusetts Institute of Technology: "How can people and computers be connected so that – collectively – they act more intelligently than any individuals, groups, or computers have ever done before" (see http://cci.mit.edu). It is important to note that this notion of CI encompasses people *and* computers.

Our understanding of how information systems may help to resolve wicked problems is still in its infancy. Research has shown that wicked problems typically cannot be resolved by pure computing power. Computing power is effective on well-defined problems, which can be formalized, but wicked problems are poorly defined, with some aspects of the relevant knowledge being tacit, unstructured, and neither easily captured nor easily codified. The underlying complexity of wicked problems comes from the fact that they are problems complicated by social interactions that are fluid, evolving, and involve conflicting interests. Resolving wicked problems requires parallel discourse, multiple iterations, changes of beliefs, and unpredictable revisions. Outcomes may be emergent and depend on the intensity, quality, and perception of contributions over time and may never be final or "true" in an absolute, agreed-upon sense.

Given the complexity of wicked problems, it should come as no surprise that more recent research streams such as "human computation", "human sensing", "the human grid", "citizen science" (Cohn 2008; Bonney et al. 2009) and so on show that humans are better suited for many tasks than computers (popular examples include Amazon's mechanical Turk) (Brynjolfsson and McAfee 2012, pp. 53–60). Still, information systems can contribute a lot, not by pursuing the automation paradigm of IS but by extending the support paradigm as exemplified by Computer-Supported Cooperative Work (CSCW).

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[1]For different interpretations of the term "social media" see Kaplan and Haenlein (2010, pp. 59–68); Kietzmann et al. (2011, pp. 241–251).

Examples of needed functionality as part of information systems with regard to wicked problems include (Schoder et al. 2013b):

- Supporting deliberation, that is, the "process where communities (1) identify possible solutions for a problem, and (2) select the solution(s) from this space that best meet(s) their diverse needs" (Klein 2012, p. 449);
- helping knowledge workers navigate social graphs (link prediction, identifying relevant individuals, assessing the strength of ties, assessing the embeddedness and position of individuals, etc.);
- highlighting relevant documents based on their processing through social interactions (who is using or working on documents, in which social position and context, and does this indicate relevance?);
- exploiting human computation;
- creating individualized information cockpits that monitor topical domains in a customized way (including hot topic identification and predictive capabilities of how things, items, issues, people, etc. may evolve); and
- coping with large collections of semi-structured or unstructured data, technically as well as semantically.

The desired functionality and required improved understanding of appropriate information systems can be expressed in at least six sets of research challenges (see **Table 1**):

Systems Engineering for Large-Scale CI Applications   The first set of research challenges concerns systems engineering which tackles functionality, technical design, and modeling aspects: Which models, methods and languages are the most appropriate for designing IS for wicked problems? Although there is a plethora of articles dealing with system design for small- and medium-size platforms for collaboration (e.g., in the domain of computer-supported cooperative work), our understanding is still limited regarding CI applications suitable to support interaction among thousands if not hundreds of thousands of people collaborating simultaneously and cross-organizationally on a single issue. Prediction market research is a notable exception (e.g., Tziralis and Tatsiopoulos 2007, pp. 75–91); prediction markets try to harness collective intelligence of a large number of (rather independent) trading

Table 1   Research challenges

Systems engineering for large-scale CI applications
Measuring, such as discourse and CI
Big Data management
Semantic content analysis
Human-computer interfacing
Commercialization of CI applications and application scenarios

agents. Nevertheless, gaining an understanding of how to harness collective intelligence of large groups of people is as relevant as how to harness collective intelligence of small groups.

Measuring, such as Discourse and CI   The second set of research challenges, in general terms, concerns measurement. "The better we measure, the better we manage", as the old adage goes. It seems crucial to measure what is going on in a discourse concerned with wicked problems. Also, it would be helpful to have measures specific for people with particular expertise aimed at best allocation of knowledge; this could or should be part of specific discourse. For example, insight into how CI can be measured may help with classic knowledge worker tasks including team formation and assigning and tailoring workloads in an effective way. The motivation for measuring collective intelligence is similar to the motivation for measuring individual intelligence (cf. Deary 2000). Measuring individual intelligence is undoubtedly one of the prominent tasks in psychology research. However, there have been very few efforts to measure group intelligence (Woolley et al. 2010, pp. 686–688). Social psychologists have not yet attempted to measure group intelligence in the same way in which they measure individual intelligence (Woolley et al. 2010, pp. 686–688).

Big Data Management   The third set of research challenges concerns data handling: How can we cope with (large) amounts of discourse-induced data in terms of quantity, flow characteristics, and (most often weak) structuring? In the context of social media, the increasing amount of data is reflected in various phenomena. For example, statistics published by Wikipedia claim that the number of articles in the English-language Wikipedia increased from 3.8 million in January 2012 to 4.1 million in January 2013. This corresponds to about

800 articles per day (http://en.wikipedia.org/wiki/Wikipedia:Size_of_Wikipedia). The micro-blogging platform Twitter claims that more than 400 tweets are sent each second, and the Chinese micro-blogging service Sina Weibo reports more than 300 million registered users in just three years (Schoder et al. 2013b, pp. 9–15). However, techniques for the analysis of such data (e.g., text mining, Web mining, social network analysis, and spatial-temporal analysis) are not yet well integrated into existing collaborative work systems. Furthermore, methods for the analysis of social media data that are generated in the "Web 3.0" (i.e., data from mobile phones, tablets, and other sensor-based systems) are still far from being well developed (Chen et al. 2012, pp. 1165–1188).

Semantic Content Analysis   The fourth set of research challenges focuses on dealing semantically with content. Content analysis at a semantic level has many facets, each of which poses quite diverse challenges. Computer vision and speech recognition aim to detect and analyze content and context, but can also be the starting point for translating non-textual audio-visual content (such as video or speech) to text as an intermediate representation for analysis. Information extraction, natural language processing, or related sub-disciplines (such as opinion mining) provide research fields which focus on the quest for semantic meaning in textual content. Here, challenges such as detecting topics or semantic orientation (sentiment) are often modeled as text classification problems to be addressed by machine learning algorithms (Sebastiani 2002, pp. 1–47) such as Naive Bayes or Support Vector Machines (Joachims 1998). These operate on different levels of supervision (supervised, semi-supervised, or unsupervised) and may include "relevance feedback" loops. Challenges in deriving semantic meaning also occur at different levels of granularity, such as the level of the complete document collection itself, of the document,

of the section, or even at the level of individual phrases. Fields are the detection of topic (Brants et al. 2002, pp. 211–218), genre (Kessler et al. 1997, pp. 32–38), as well as subjectivity and/or sentiment (Liu 2010, pp. 627–666; Pang et al. 2002, pp. 79–86; Turney 2002, pp. 417–424), whereas the complexity of human language leads to multiple challenges such as detecting negations (Councill et al. 2010, pp. 51–59), sarcasm and irony (Carvalho et al. 2009, pp. 53–56), or opinion spam (Jindal and Liu 2008, pp. 219–230), and the detection/resolutions of synonyms (Baroni and Bisi 2004) or anaphora (Lappin and Leass 1994, pp. 535–561) and co-references (Soon et al. 2001, pp. 741–757).

Human-Computer Interfacing The fifth set of research challenges focuses on linking humans and computers: How can humans and computers be combined in problem-solving networks? The motivation for this research question is twofold. On the one hand, we are heading towards a good understanding of human networks (e.g., Wasserman and Faust 1994) as well as of computer networks. On the other hand, we do not yet know much about "two-mode networks" consisting of humans and computers (von Ahn 2005).

Commercialization of CI Applications and Application Scenarios The sixth set of research challenges concerns the commercialization (i.e., business models) of applications and application scenarios. For the given context, Zott et al. (2011, pp. 1019–1042) provide an extensive literature review of business model research. In their stream of thought, IS researchers can contribute in particular to research on "e-business model archetypes". Such research has its origin in e-Commerce research and can be organized around two complementary streams of thought: one aims to provide typologies (and describes generic e-business models); the other focuses on the components of e-business models. It is evident that social media facilitate new business models. For example, several authors examine Facebook's business model (e.g., Krombholz et al. 2012, pp. 175–212). However, little is known about business models that focus on harnessing collective intelligence with social media, and thus we may miss the potential of creating incentives for economic

players that induce a infrastructure for wicked problems.

In the next section, we point to prospective scientific methods suitable for tackling the research challenges.

3 Prospective Scientific Methods

Taking on some of the aforementioned exemplary features as part of information systems with regard to wicked problems, a vast set of very promising scientific methods is already deployed.

The support of knowledge workers in navigating social graphs can be tackled with methods from social network analysis (SNA) (e.g., Cross et al. 2005), an interdisciplinary research paradigm that mainly utilizes graph theory to examine how people are connected. Five particular areas of SNA research are of interest. The first research area includes algorithms for the visualization of networks and calculation of network statistics (e.g., Borgatti et al. 2002; Brandes 2001, pp. 163–177; De Nooy et al. 2005; Krempel 2005). The second area comprises models that examine the evolution of networks (e.g., Doreian and Stokman 1997; Robins et al. 2007, pp. 192–215; Snijders et al. 2009, pp. 44–60; Wasserman and Pattison 1996, pp. 401–425). The third includes work dealing with scale free networks and complex systems (e.g., Barabasi and Albert 1999, p. 509; Newman 2006, p. 8577; Watts et al. 2007, pp. 22–23; Watts and Strogatz 1998, pp. 440–442). The fourth, mostly undertaken by IS researchers, uses network analysis to analyze electronic communication networks (e.g., Ahuja and Carley 1999, pp. 741–757; Ahuja et al. 2003, pp. 21–38; Ashworth and Carley 2006, pp. 43–75; Fischbach et al. 2009, pp. 1–8; Wasko et al. 2009, pp. 254–265; Kane et al. forthcoming). Finally, the fifth area of research comprises research in management science and sociology that focuses on the association between network structure and the performance of actors embedded in the networks (see Borgatti and Foster 2003, pp. 991–1013; Brass et al. 2004, pp. 795–817, for a literature review of these works in organizational research).

Highlighting relevant documents based on their processing by social interactions can be tackled with methods from CSCW. For example, in the context of groupware, researchers examined the performance of different technologies

for creating context awareness in Web browsers (Gutwin et al. 2011, pp. 167–176). These findings can help us develop the envisioned super large-scale group decision support systems using Web technologies.

The integration of humans into computational tasks can be addressed with methods from human computation, defined as "a paradigm for utilizing human processing power to solve problems that computers cannot yet solve" (von Ahn 2005, p. 3). Its power comes from its use of games designed to engage humans in collaborating, sometimes without their knowledge, which may be one of its main distinctions from the other methods mentioned above (Quinn and Bederson 2011, pp. 1403–1412; Kearns 2012, pp. 58–67). An adjacent avenue of research scrutinizes human beings acting as sensors, thus exercising what is called human sensing, crowd data sensing or public data sensing (Austen 2013, pp. 48–51). Conti et al. (2012, pp. 2–21) frame a broader picture in terms of convergent cyber-physical systems. They discuss the phenomenon that a wave of (human) social networks and structures are emerging as important drivers for the development of novel communication and computing paradigms.

The task to create individualized information cockpits that monitor topical domains in a customized way can be tackled with methods from data mining such as association rules, clustering, decision trees, k-nearest neighbor, or neural networks (see Park et al. 2012, pp. 10059–10072, for a literature review).

The problem of coping technically with large collections of semi- or unstructured data can be tackled with methods and programming models such as MapReduce (e.g., Dean and Ghemawat 2008, pp. 107–113) (e.g., Apache Hadoop) that facilitate the analysis of large amounts of data, often called "Big Data" (see Chen et al. 2012, pp. 2265–1188, for an overview of these methods). There is a large body of research on how to cope semantically with large collections of semi- or unstructured data (i.e., text), including methods from machine learning (e.g., Bishop 2006), data mining (e.g., Liu 2007), text mining (Feldman and Sanger 2006), and sentiment analysis (Pang and Lee 2008). These methods open up unprecedented opportuni-

4 Examples of Initial Results

Among the papers at the intersection of social media and collective intelligence with respect to information systems research for "wicked problems", several research domains have attracted particular attention in IS research and may provide examples of initial results. We would here like to highlight four research domains.

(1) The first research domain comprises deliberation technologies. Klein (2012, pp. 449–473) reviews a wide range of social computing technologies that have emerged in the past few decades. To understand the strengths and limitations of deliberation technologies more fully, he groups functionality as either "time-centric" or "topic-centric". Obviously, there is a lot of significant research on deliberation technology. However, to leverage and extend this research to large-scale argumentation systems, there is a need for more argumentation-centric approaches (e.g., Gürkan et al. 2010, pp. 3686–3702).

(2) The second domain comprises work that proposes methods and artifacts for harnessing collective intelligence from wikis. For example, researchers have proposed an alternative search interface for Wikipedia (Hahn et al. 2010, pp. 1–11); others examined the influence of the number of editors on the collective knowledge created in Wikipedia (Kittur et al. 2009, pp. 1495–1504). Other authors used methods from machine learning to improve the quality of an organization's corporate wiki and, in doing so, assigned wiki articles to experts for further review and contribution (Lykourentzou et al. 2010, pp. 18–38). Researchers have examined wiki-like systems such as a collective intelligence system for crime reports (Furtado et al. 2010, pp. 4–17) and a system for real-time traffic information (Lee et al. 2010, pp. 62–70). Finally, Passant & Laublet (2008, pp. 58–69) present a wiki-farm system to produce ontology-based data that are understandable for humans and computers, which leads to the third research domain.

(3) The third research domain is collective intelligence and data categorization. According to Levy (2010, pp. 71–94), one of the most prominent researchers in the domain of CI, useful data categorization is a core problem of CI management in commercial enterprises. Hence,

several researchers regard social tagging and the resulting folksonomies as a main CI research question (e.g., Floeck et al. 2011, pp. 75–91; Gregg 2010, pp. 134–138; Gruber 2007, pp. 1–11; Hsieh et al. 2009, pp. 9513–9523; Vanderhaeghen et al. 2010, pp. 15–28). Social tagging refers to the process by which users bookmark objects – often on the Internet and thus – identified by their Unified Resource Locators (URLs) – and annotate those objects with metadata, or so-called tags. The set of tags that results over all users' annotations is denoted folksonomy, a neologism derived from folk and taxonomy (see Gruber 2007, pp. 1–11, for a discussion of the ontology of folksonomy). There is some dispute in the literature over the contexts in which folksonomies are more or less appropriate for content classification and categorization than taxonomies created by experts (see, e.g., Hsieh et al. 2009, pp. 9513–9523, for a comparison of taxonomies and folksonomies). Therefore, design science approaches suggest artifacts that employ social tagging for harnessing the collective intelligence in enterprises. For example, Vanderhaeghen et al. (2010, pp. 15–28) illustrate how social tagging can be applied in process management. They propose and discuss a structure, model, and prototype.

(4) The fourth research domain comprises papers that deal with prediction markets, which many CI researchers cite as a prime example for harnessing collective intelligence (e.g., Bonabeau 2009; pp. 45–52; Bothos et al. 2009, pp. 26–41; Malone et al. 2010, pp. 21–31). Research into predictions is a mature field of study of its own. For example, The Journal of Prediction Markets debuted in 2007. Therefore, we do not review this field of study in this commentary, but rather point to the literature review by Tziralis and Tatsiopoulos (2007, pp. 75–91) as well as the contributions by Forsythe, Nelson, Neumann and Wrigt (1992, pp. 1142–1161), Spann and Skiera (2003, pp. 1310–1326), Servan-Schreiber, Wolfers, Pennock and Galebach (2004, pp. 243–251), and Arrow and colleagues (2008, pp. 877–878).

5 Conclusion

Wicked problems are one of the most challenging problem classes ever encountered, and we are only in an early phase

of understanding their complexities. Unfortunately, most grand challenges share characteristics of wicked problems. The need for appropriate information systems or – more specifically – useful functionality to harness the collective intelligence of crowds is not disputed and can constitute a solid research claim. The scale and scope of the proposed research calls for interdisciplinary approaches. We can expect that IS/Business and Information Systems Engineering (BISE) research will benefit from academic discourse with computer science, sociology, psychology, anthropology, and media studies – to name only the most prominent fields, but not ruling out additional disciplines.

For example, computer scientists have developed methods and tools that include data capture, curation, storage, search, sharing, transfer, analysis, and visualization. Sociologists can contribute to our understanding of the interplay of social media and collective intelligence. As highlighted above, (social) network analysis is a core methodology for understanding how humans (and computers) need to be connected to act more intelligently than individuals, groups, or computers have ever done before. Like many other theories that help us understand the social processes leading to collective intelligence, social network analysis has its roots in sociology (e.g., Scott 2010, pp. 21–26). From psychology, we can borrow motivational theories; from anthropology, ethnographic approaches; from media studies, for instance, agenda-setting theories, content analysis, discourse analysis, effects theories, theories of persuasion, or uses and gratifications theory.

IS as a scientific discipline may be applauded for being in a pole position likely to contribute significantly to the proposed research: IS research takes a two-pronged perspective that is particularly fruitful given the rich research questions that almost always simultaneously include "man" and "machine" aspects as well as socioeconomic dimensions. IS research needs to undertake the difficult balancing act of combining behavioristic research approaches with design-oriented research approaches. In doing so, it tends not to favor one over the other, which makes it particularly vulnerable to criticism from both research communities, since both communities use the same language to describe different phenomena and have different beliefs about

ties for the analysis of (social) media and collective intelligence.

Abstract

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The objective of this commentary is to propose fruitful research directions built upon the reciprocal interplay of social media and collective intelligence. We focus on "wicked problems" – a class of problems that Introne et al. (Künstl. Intell. 27:45–52, 2013) call "problems for which no single computational formulation of the problem is sufficient, for which different stakeholders do not even agree on what the problem really is, and for which there are no right or wrong answers, only answers that are better or worse from different points of view". We argue that information systems research in particular can aid in designing appropriate systems due to benefits derived from the combined perspectives of both social media and collective intelligence. We document the relevance and timeliness of social media and collective intelligence for business and information systems engineering, pinpoint needed functionality of information systems for wicked problems, describe related research challenges, highlight prospective suitable methods to tackle those challenges, and review examples of initial results.

Keywords: Collective intelligence, Knowledge work, Research agenda, Research commentary, Social media, Wicked problems

what constitutes rigorous and relevant research (see, for example, the discussion in Baskerville et al. 2011, pp. 11–15; Buhl et al. 2012a, pp. 307–315; Buhl et al. 2012b, pp. 236–253; Junglas et al. 2011, pp. 1–6; Österle et al. 2010, pp. 7–10). To understand and build effective artifacts, both approaches are complementary and both are indeed necessary.

We hope that the two-pronged perspective of IS research in particular will be extended to the intersection of social media and collective intelligence, stimulating the design of function-rich information systems for wicked problems.

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References

Ahuja MK, Carley K (1999) Network structure in virtual organizations. Organ Sci 10(6):741–757

Ahuja MK, Galletta DF, Carley KM (2003) Individual centrality and performance in virtual R&D groups: an empirical study. Manag Sci 49(1):21–38

Alavi M, Leidner DE (2001) Review: knowledge management and knowledge management systems: conceptual foundations and research issues. Manag Sci 25(1):107–136

Arrow KJ, Forsythe R, Gorham M, Hahn R, Hanson R, Ledyard JO, Levmore S, Litan R, Milgrom P, Nelson FD, Neumann GR, Ottaviani M, Schelling TC, Shiller RJ, Smith VL, Snowberg E, Sunstein CR, Tetlock PC, Tetlock PE, Varian HR, Wolfers J, Zitzewitz E (2008) Economics – the promise of prediction markets. Science 320(5878):877–878

Ashworth M, Carley K (2006) Who you know vs. what you know: the impact of social position and knowledge on team performance. J Math Sociol 30(1):43–75

Austen K (2013) Out of the lab and onto the streets. New Sci 218(2932):48–51

Barabasi A, Albert R (1999) Emergence of scaling in random networks. Science 286(5439):509

Baroni M, Bisi S (2004) Using cooccurrence statistics and the web to discover synonyms in a technical language. In: Proceedings of LREC, Lisbon, pp 1725–1728

Baskerville R, Lyytinen K, Sambamurthy V, Straub D (2011) A response to the design-oriented information systems research memorandum. Eur J Inf Syst 20(1):11–15

Bishop CM (2006) Pattern recognition and machine learning, vol 4. Springer, Heidelberg

Bjelland OM, Wood RC 2008 An inside view of IBM's 'innovation jam'. MIt Sloan Manag Rev Fall 50(1):32–40

Boll S, Jain R, Luo JB, Xu D (2011) Introduction to special issue on social media. ACM Trans Multimed Comput 7(Supplement):25

Bonabeau E (2009) Decisions 2.0: the power of collective intelligence. Sloan Manag Rev 50(2):45–52

Bonney R, Cooper C, Dickinson J, Kelling S, Phillips T, Rosenberg K, Shirk J (2009) Citizen science: a developing tool for expanding science knowledge and scientific literacy. BioScience 59(11):977–984

Borgatti SP, Foster PC (2003) The network paradigm in organizational research: a review and typology. J Manag 29(6):991–1013

Borgatti SP, Everett M, Freeman L (2002) Ucinet for Windows: software for social network analysis. Analytic Technologies, Harvard

Bothos E, Apostolou D, Mentzas G (2009) Collective intelligence for idea management with Internet-based information aggregation markets. Internet Res 19(1):26–41

Brandes U (2001) A faster algorithm for betweenness centrality. J Math Sociol 25(2):163–177

Brants T, Chen F, Tsochantaridis I (2002) Topic-based document segmentation with probabilistic latent semantic analysis. In: Proc of 11th international conference on information and knowledge management, New York, pp 211–218

Brass DJ, Galaskiewicz J, Greve HR, Tsai WP (2004) Taking stock of networks and organizations: a multilevel perspective. Acad Manag J 47(6):795–817

Brynjolfsson E, McAfee A (2012) Winning the race with ever-smarter machines. Sloan Manag Rev 53(2):53–60

Buhl HU, Fridgen G, Müller G, Röglinger M (2012a) On dinosaurs, measurement ideologists, separatists, and happy souls – proposing and justifying a way to make the global IS/BISE community happy. Bus Inf Syst Eng 4(6):307–315

Buhl HU, Müller G, Fridgen G, Röglinger M (2012b) Business and information systems engineering: a complementary approach to information systems – what we can learn from the past and may conclude from present reflection on the future. J Assoc Inf Syst 13(4):236–253

Carvalho P, Sarmento L, Silva MJ, De Oliveira E (2009) Clues for detecting irony in user-generated contents: oh...!! It's "so easy" ;-). In: Proc of 1st international CIKM workshop on topic-sentiment analysis for mass opinion. ACM, New York, pp 53–56

Chen HC, Yang CC (2011) Special issue on social media analytics: understanding the pulse of the society. IEEE Trans Syst Man Cybern 41(5):826–827

Chen H, Chiang RHL, Storey VC (2012) Business intelligence and analytics: from big data to big impact. MIS Quart 36(4):1165–1188

Churchman CW (1967) Wicked problems. Manag Sci 14(4):B-141–B-142

Cohn JP (2008) Citizen science: can volunteers do real research? BioScience 58(3):192–207

Conti M, Das SK, Bisdikian C, Kumar M, Ni LM, Passarella A, Roussos G, Tröster G, Tsudik G, Zambonelli F (2012) Looking ahead in pervasive computing: challenges and opportunities in the era of cyber-physical convergence. Pervasive Mob Comput 8(1):2–21

Cortizo JC, Carrero FM, Gomez JM (2011) Introduction to the special issue: mining social media. Int J Electron Commer 15(3):5–7

Councill IG, McDonald R, Velikovich L (2010) What's great and what's not: learning to

classify the scope of negation for improved sentiment analysis. In: Proc workshop on negation and speculation in natural language processing, pp 51–59. Association for Computational Linguistics

Cross R, Liedtka J, Weiss L (2005) A practical guide to social networks. Harv Bus Rev 83(3):124–132

Davenport TH, Prusak L (1998) Working knowledge. Harvard Business School Press, Boston

Davenport TH, De Long DW, Beers MC (1998) Successful knowledge management projects. Sloan Manag Rev 39(2):43–57

De Nooy W, Mrvar A, Batagelj V (2005) Exploratory social network analysis with Pajek. Cambridge University Press, New York

Dean J, Ghemawat S (2008) MapReduce: simplified data processing on large clusters. Commun ACM 51(1):107–113

Deary IJ (2000) Looking down on human intelligence – from psychometrics to the brain. Oxford University Press, New York

Doreian P, Stokman FN (1997) Evolution of social networks. Gordon and Breach, Amsterdam

European Commission (2009) The world in 2025. http://ec.europa.eu/research/social-sciences/pdf/the-world-in-2025-report_en.pdf. Accessed 2012-07-01

Feldman R, Sanger J (2006) The text mining handbook: advanced approaches in analyzing unstructured data. Cambridge University Press, New York

Finholt TA (2002) Collaboratories. Annu Rev Inf Sci Technol 36(1):73–107

Fischbach K, Gloor PA, Schoder D (2009) Analysis of informal communication networks – a case study. Bus Inf Syst Eng 1(2):140–149

Floeck F, Putzke J, Steinfels S, Fischbach K, Schoder D (2011) Imitation and quality of tags in social bookmarking systems – collective intelligence leading to folksonomies. In: Bastiaens T, Baumöl U, Krämer B (eds) Advances in soft computing, on collective intelligence, vol 76. Heidelberg, Springer, pp 75–91

Forsythe R, Nelson F, Neumann GR, Wright J (1992) Anatomy of an experimental political stock-market. Am Econ Rev 82(5):1142–1161

Furtado V, Ayres L, de Oliveira M, Vasconcelos E, Caminha C, D'Orleans J, Belchior M (2010) Collective intelligence in law enforcement — the WikiCrimes system. Inf Sci 180(1):4–17

Gregg D (2009) Developing a collective intelligence application for special education. Decis Support Syst 47(4):455–465

Gregg D (2010) Designing for collective intelligence. Commun ACM 53(4):134–138

Gruber T (2007) Ontology of folksonomy: a mash-up of apples and oranges. Int J Semantic Web Inf Syst 3(1):1–11

Gürkan A, Iandoli L, Klein M, Zollo G (2010) Mediating debate through on-line large-scale argumentation: evidence from the field. Inf Sci 180(19):3686–3702

Gutwin CA, Lippold M, Graham TCN (2011) Real-time groupware in the browser: testing the performance of web-based network. In: Proc of ACM 2011 conference on computer supported cooperative work (CSCW 2011), Hangzhou, pp 167–176

Hahn R, Bizer C, Sahnwaldt C, Herta C, Robinson S, Burgle M, Duwiger H, Scheel U (2010) Faceted Wikipedia search. Lect Notes Bus Inf 47:1–11

Hiltz SR, Johnson K, Turoff M (1991) Group decision support: the effects of designated human leaders and statistical feedback in computerized conferences. J Manag Inf Syst 8(2):81–108

Hiltz SR, Diaz P, Mark G (2011) Introduction: social media and collaborative systems for crisis management. ACM Trans Comput-Hum Interact 18(4):18

Hsieh WT, Stu J, Chen YL, Chou SCT (2009) A collaborative desktop tagging system for group knowledge management based on concept space. Expert Syst Appl 36(5):9513–9523

Introne J, Laubacher R, Olson G, Malone T (2013) Solving wicked social problems with socio-computational systems. Künstl Intell 27:45–52

Jindal N, Liu B (2008) Opinion spam and analysis. In: Proc of international conference on web search and web data mining. ACM, New York, pp 219–230

Joachims T (1998) Text categorization with support vector machines: learning with many relevant features. Lect Notes Comput Sci 139:137–142

Junglas I, Niehaves B, Spiekermann S, Stahl BC, Weitzel T, Winter R, Baskerville R (2011) The inflation of academic intellectual capital: the case for design science research in Europe. Eur J Inf Syst 20(1):1–6

Kane GC, Alavi M, Labianca G, Borgatti SP (in press) What's different about social media networks? A framework and research agenda. MIS Quarterly

Kapetanios E, Koutrika G (2010) Guest editorial: special issue on collective intelligence. Inf Sci 180(1):1–3

Kaplan AM, Haenlein M (2010) Users of the world, unite! The challenges and opportunities of social media. Bus Horiz 53(1):59–68

Kearns M (2012) Experiments in social computation. Commun ACM 55(10):58–67

Kessler B, Numberg G, Schütze H (1997) Automatic detection of text genre. In: Proc of 35th annual meeting of the association for computational linguistics and eighth conference of the European chapter of the association for computational linguistics, pp 32–38. Association for Computational Linguistics

Kietzmann JH, Hermkens K, McCarthy IP, Silvestre BS (2011) Social media? Get serious! Understanding the functional building blocks of social media. Bus Horiz 54(3):241–251

Kittur A, Lee B, Kraut RE (2009) Coordination in collective intelligence: the role of team structure and task interdependence. In: Proceedings of the 27th annual chi conference on human factors in computing systems (Chi2009), Boston, pp 1495–1504

Klein M (2012) Enabling large-scale deliberation using attention-mediation metrics. Comput Support Coop Work 21:449–473

Krempel L (2005) Visualisierung komplexer Strukturen: Grundlagen der Darstellung mehrdimensionaler Netzwerke. Campus, Frankfurt

Krombholz K, Merkl D, Weippl E (2012) Fake identities in social media: a case study on the sustainability of the Facebook business model. J Serv Sci Res 4(2):175–212

Lappin S, Leass HJ (1994) An algorithm for pronominal anaphora resolution. Comput Linguist 20(4):535–561

Lee WH, Tseng SS, Shieh WY (2010) Collaborative real-time traffic information generation and sharing framework for the intelligent transportation system. Inf Sci 180(1):62–70

Leimeister JM (2010) Collective intelligence. Bus Inf Syst Eng 2(4):245–248

Levy P (2010) From social computing to reflexive collective intelligence: the IEML research program. Inf Sci 180(1):71–94

Liang TP, Turban E (2011) Introduction to the special issue social commerce: a research framework for social commerce. Int J Electron Commer 16(2):5–13

Liu B (2007) Web data mining: exploring hyperlinks, contents, and usage data. Heidelberg, Springer

Liu B (2010) Sentiment analysis and subjectivity. In: Indurkhya N, Damerau F (eds) Handbook of natural language processing, 2nd edn. CRC, London, pp 627–666

Luo SL, Xia HX, Yoshida T, Wang ZT (2009) Toward collective intelligence of online communities: a primitive conceptual model. J Syst Sci Syst Eng 18(2):203–221

Lykourentzou I, Papadaki K, Vergados DJ, Polemi D, Loumos V (2010) CorpWiki: a self-regulating wiki to promote corporate collective intelligence through expert peer matching. Inf Sci 180(1):18–38

Mertens P, Barbian D (2013) Forschung über „Grand Challenges" – Eine „Grand Challenge". Arbeitspapier Nr 1/2013, Universität Erlangen-Nürnberg

Malone TW, Laubacher R, Dellarocas C (2010) The collective intelligence genome. Sloan Manag Rev 51(3):21–31

nA (2009) The lund decleration – Europe must focus on the grand challenges of our time. http://www.vr.se/download/18.7dac901212646d84fd38000336/1264064126033/Lund_Declaration.pdf. Accessed 2012-07-01

Newman M (2006) Modularity and community structure in networks. Proc Natl Acad Sci USA 103(23):8577

Österle H, Becker J, Frank U, Hess T, Karagiannis D, Krcmar H, Loos P, Mertens P, Oberweis A, Sinz EJ (2010) Memorandum on design-oriented information systems research. Eur J Inf Syst 20(1):7–10

Pang B, Lee L (2008) Opinion mining and sentiment analysis. Now Pub, Hannover

Pang B, Lee L, Vaithyanathan S (2002) Thumbs up? Sentiment classification using machine learning techniques. In: Proc of EMNLP 2002, Philadelphia, pp 79–86

Park DH, Kim HK, Choi IY, Kim JK (2012) A literature review and classification of recommender systems research. Expert Syst Appl 39(11):10059–10072

Passant A, Laublet P (2008) Combining structure and semantics for ontology-based corporate wikis. Lect Notes Bus Inf 7:58–69

Robins G, Snijders T, Wang P, Handcock M, Pattison P (2007) Recent developments in exponential random graph (p*) models for social networks. Soc Netw 29(2):192–215

Quinn A, Bederson B (2011) Human computation: a survey and taxonomy of a growing field. In: CHI 2007, Vancouver, pp 1403–1412

Rittel HWJ, Weber MM (1973) Dilemmas in a general theory of planning. Policy Sci 4(2):155–169

Schoder D, Gloor P, Metaxas PT (2013a) Special issue on social media (editorial). Künstl Intell 27(1):5–8

Schoder D, Gloor P, Metaxas PT (2013b) Social media and collective intelligence – ongoing and future research streams. Künstl Intell 27(1):9–15

Scott J (2010) Social network anylsis – a handbook, 2nd ed. Sage Publications, Thousand Oaks.

Sebastiani F (2002) Machine learning in automated text categorization. ACM Comput Surv 34(1):1–47

Servan-Schreiber E, Wolfers J, Pennock DM, Galebach B (2004) Prediction markets: does money matter? Electron Mark 14(3):243–251

Snijders TAB, van de Bunt GG, Steglich CEG (2009) Introduction to stochastic actor-based models for network dynamics. Soc Netw 32(1):44–60

Soon WM, Ng HT, Lim DCY (2001) A machine learning approach to coreference resolution of noun phrases. Comput Linguist 27(4):521–544

Spann M, Skiera B (2003) Internet-based virtual stock markets for business forecasting. Manag Sci 49(10):1310–1326

Turney PD (2002) Thumbs up or thumbs down? Semantic orientation applied to unsupervised classification of reviews. In: Proc of 40th annual meeting on association for computational linguistics, pp 417–424. Association for Computational Linguistics

Tziralis G, Tatsiopoulos I (2007) Prediction markets: an extended literature review. J Predict Mark 1(1):75–91

Vanderhaeghen D, Fettke P, Loos P (2010) Organizational and technological options for business process management from the perspective of web 2.0 results of a design oriented research approach with particular consideration of self-organization and collective intelligence. Bus Inf Syst Eng 2(1):15–28

von Ahn L (2005) Human computation. PhD thesis, Carnegie Mellon University

Wasko M, Teigland R, Faraj S (2009) The provision of online public goods: examining social structure in an electronic network of practice. Decis Support Syst 47(3):254–265

Wasserman S, Faust K (1994) Social network analysis: methods and applications. Cambridge University Press, Cambridge

Wasserman S, Pattison P (1996) Logit models and logistic regressions for social networks. I. An introduction to Markov graphs and p^*. Psychometrika 61(3):401–425

Watts D, Strogatz S (1998) Collective dynamics of 'small-world' networks. Nature 393(6684):440–442

Watts D, Peretti J, Frumin M (2007) Viral marketing for the real world. Harv Bus Rev 85(5):22–23

Woolley AW, Chabris CF, Pentland A, Hashmi N, Malone TW (2010) Evidence for a collective intelligence factor in the performance of human groups. Science 330(6004):686–688

Zott C, Amit R, Massa L (2011) The business model: recent developments and future research. J Manag 37(4):1019–1042