Overview of the Balancing Pervasive Information Systems Project and a Call for Research Collaborations

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Abstract: The Research on Balancing Theories and Mechanisms to Pervasive Information Systems (B2P) is one of the component studies of the Records-centered Digital Information Management Theory and Mechanisms (DI{R}Mtm) Project, which aims pointedly at synchronizing records/information related research interests with the evolution of information technologies and their joint impact on society. Due to the breakthroughs in cloud computing, big data, the Internet of Things and artificial intelligence, ubiquitous/pervasive computing, conceived in 1988, has now been rapidly advanced. As its materialization in organizations, pervasive information systems (PISs) converges information technologies, data, digital operations and human actors and functions as the main channel for digital decisions. Digital decisions, therefore, are autonomous, algorithmic and penetrating, possessing influential abilities that are much greater than any single technology in human history, including the Internet. Such abilities make it a strong force for societal advancement, yet, at the same time, a potential hurdle – even harm – for decision recipients who are unaware of the decision-making methods. The B2P study is conceived as a reaction to this phenomenon. This paper gives an overview of the B2P study and calls for collaborations among researchers from the various fields relevant to the aims of the study, i.e., archival science, records management, information science, pubic administration, law, social sciences, and computer sciences.

1 INTRODUCTION

The Balancing Pervasive Information Systems Project, fully entitled as Research on Balancing Theories and Mechanisms to Pervasive Information Systems (B2P), is one of the component studies of the Records-centered Digital Information Management Theory and Mechanisms (DI{R}Mtm) Project. The DI{R}Mtm project, founded by the Fundamental Research Funds for Central Universities and the Research Funds of Renmin University of China (15XNL032), is currently at its second phase (2018 – 2020), which, as suggested by the findings of the first phase of the DI{R}Mtm project, aims more pointedly at synchronizing research interests with the evolution of information technology. This paper gives an overview of the B2P study and calls for collaborations among researchers from the various fields relevant to the aims of the study, i.e., archival science, records management, information science, pubic administration, law, social sciences, and computer sciences.

2 STUDY OBJECTS

The study objects of the B2P study include two major topics: pervasive information systems and the issue with digital decision accountability.

2.1 Pervasive Information Systems

Pervasive information systems (PISs) is an emerging paradigm in the field of information systems (ISs), which emphasizes pervasiveness. The idea of pervasiveness is in concert with the visions of ubiquitous computing (UbiCom) and (the later on) pervasive computing (PerCom), all aiming at "integrating computers seamlessly into the world" (Weise, 1991). PISs, therefore, can be viewed as an

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assembly of information technologies that extends ISs from traditionally a PC network into a web of heterogeneous cooperating/communicating objects, both inside and outside the physical boundary of organizations. At present, the assembly includes technologies such as artificial intelligence (AI), big data (BD), the Internet of Things (IoT), and cloud computing (CloudCom), all of which – termed as PISs component technologies in this application – possess with each other interrelated relationships. Relying on the entry relationships of the Library of Congress Subject Heading (LCSH) (LC, 2018) and the subject relationships of the databases of Academic Search Complete and Business Source Complete (ASC.BSC) (EBSCO, 2018), Figure 1 displays the relationships among the PISs component technologies (LCSH: year of entry creation; year of revision and ASC.BSC: earliest publication year).

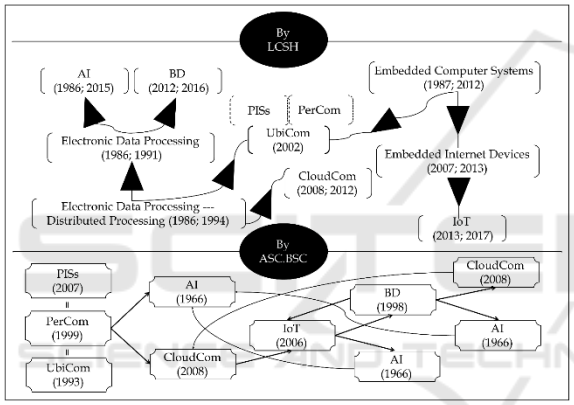

Figure 1: PISs and Its Component Technologies.

The application of PISs can be characterized as personal, domestic, corporate, and public (Kourouthanassis et al., 2010). The proposed research limits its inquires to "corporate" and refines it as organizations represented by government institutions and business corporations. This is because first, the setting of organization is the indigenous context to the origination of ISs (Davis, 1974) and second, these representative organizations typically have a more influential stance than other types of organizations, which signals research priority. Figure 2 depicts the sitting of a PISs organization in the PISs environment, where it operates with both an administrative boundary established by functions and activities and an organizational data boundary made up by diverse types of data threads supplied by the PISs component technologies. By the very nature of PISs, the organizational data boundary goes beyond the administrative boundary and it interacts dynamically with data flows from both within and outside. As such, an organizational PISs data repository pulls or receives data from other PISs organizations and at the same time, contributes data threads to the PISs data universe.

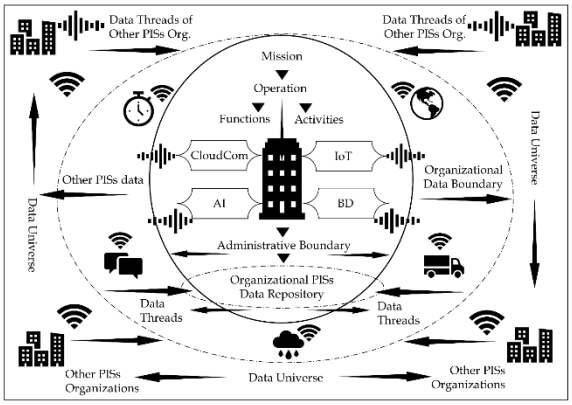

Figure 2: A PISs Organization in a PISs Environment PISs and Its Component Technologies.

Deploying PISs in organizations is now believed imperative or inevitable because of the comparative advantages (or surviving capabilities) it offers. Empowered by PISs defining features such as being embedded, distributed, context-aware, portable and real-time, organizations are becoming "smart" or "intelligent": their manners of handling both their internal and external affairs are becoming more prompt, precise and proactive. Underneath this smartness/intelligence lies one foundation – autonomous decision making, which outputs decisions without human intervention. Two main types characterize such decisions: machine/algorithm-made decisions, which are done by digital agent alone, and machine/algorithm-aided decisions, which are made jointly by human and digital agents. Digital agents here include any data processing devices or models, large or small, independent or as one part of a complex whole. As Figure 3 displays, a PISs enabled smart organization utilizes both human and digital agents in all its decision-making processes, be they strategic or transactional, and many of the decision-making processes are invisible to humans, be they human agents or human decision recipients. Indeed, being invisible to human is the ultimate goal of PISs deployment as the UbiCom idea indicates that "[t]he most profound technologies are those that disappear" (Weiser, 1991).

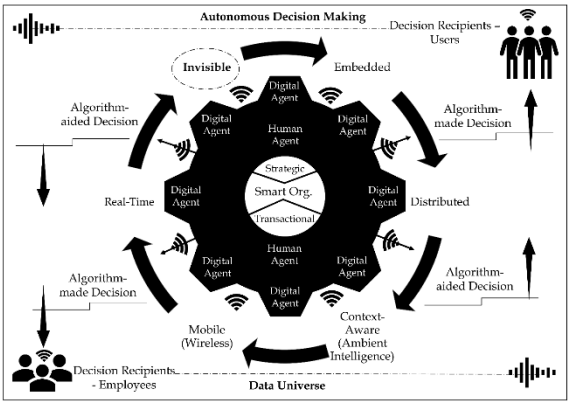

Figure 3: Characteristics of PISs Decision-Making.

As such, entities in decision making processes exhibit relationships that are dynamic and interactive, so do the made decisions in terms of the time of their existence and the way they are being delivered. Decision maker and decision recipient are two typical types of entities in decision making processes; in PISs, however, they function in a much more complicated manner. As exemplified in Figure 4, where a PISs deploying organization (dotted line) is situated in a backdrop made up by the other types of PISs organizations, decision maker has three types and decision recipient has as many as seven. For decision makers, there are PISs human agent (PISs H-Agent), PISs digital agent (PISs D-Agent), and PISs organization agent (PISs O-Agent), with the former two being considered as individual or independent unit and the later a collective whole. For decision recipients, there are:

- Potential employees of the PISs (i.e., job applicants);
- Employees of the PISs, who are also the PISs H-Agent;
- PISs users, who voluntarily make use of the services and/or products provided by the PISs deploying organization for work purposes;
- PISs consumers, who consume the services and/or products provided by the PISs deploying organization for personal purposes; and
- All the three types of decision makers.

Outside this particular PISs deploying organization are other PISs deploying organizations, either of the type of government institution or business corporation, and PISs technology organizations. The type of PISs deploying organizations together with the type of PISs technology organizations constitutes PISs controlling organization in the sense that, for the former, they control the specific deployment of PISs in their respective organizations, and for the latter, they control the underlying PISs technologies of all PISs deployments.

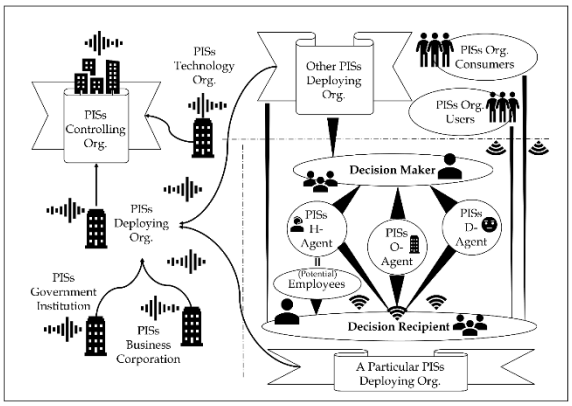

Figure 4: Entity Relationships in PISs Decision Making Environment.

These decision entities are listed as 3 types below.

Type 1: Decision Maker:

- PISs Organization
- PISs H-Agent (individual)
- PISs D-Agent (independent unit)
- PISs O-Agent (the collective whole of H-Agent and D-Agent)
- Other PISs organization

Type 2: Decision Recipient:

- For one PISs organization:
  - PISs H-Agent
  - PISs D-Agent
  - PISs O-Agent
  - PISs Consumers
- Other PISs organization
- None-PISs Organization
- PISs Potential Employee
- PISs Employee

Type 3: PISs Decision:

- Algorithm-Aided
- Work Decision: Transactional
- Work Decision: Strategic and Transactional
- Living Decision: Transactional
- Work Decision: Recruitment
- Work Decision: Performance
- Work Decision: Strategical
- Work Decision: Purchase

2.2 The Issue with Digital Decision Accountability

Emerging in this PISs environment is the concern about digital decision accountability, i.e., how PISs enabled decision-making processes can be explained and justified when legitimate inquiries arise. Accountability is a concept that offers many utilities (Jabbra and Dwivedi, 1989; Mulgan, 2000; Lindberg, 2009; Bovens, 2010) and is entangled with many other concepts such as responsibility, liability, transparency, etc. (Fox, 2007; Hood, 2010; Thompson, 2014; Castiglione, 2018). Its core, however, can always be distilled into the notion of accounting for actions or decisions. In this application, "accounting for" is furthered as two distinctive concepts, i.e., explanations and justifications. Explanations here refer to the information that answers the question how decisions were made, and justifications here refer to the information that answers the question why the decisions were so made. Together, these two types of information form what the proposed research labels as (digital decision or PISs) accountability information, which is one of the fundamental constituents of the (digital decision or PISs) accountability regime. Accountability information can be described by two aspects: the way by which it comes into existence and the way by which it participates in decision-making processes. Tightly associated with accountability information are the concepts of availability and answerability. Availability here has two forms: one from the stance of the accountor and the other from that of the accountee (both terms from Bovens, 2007). Availability for an accountor means the provision of accountability information, which is aided by the actions of keeping, identifying and delivering accountability information, and availability for accountee means the obtaining of accountability information, which requires the actions of initiating accountability inquiry and receiving accountability information. Answerability here means that the provided/received information must be able to answer the inquiry, i.e., it needs to be relevant (to the decision being questioned), sufficient (for covering the entire decision-making process), understandable (by the accountee's criteria) and credible (by commonly accepted criteria).

3 CURRENT RESEARCH

Research dedicated to accountability in PISs, including UbiCom and PerCom, does not currently exist (dedicated here refers to restricting "accountab*" in Title in databases of Web of Science and Academic Search Complete). For its components, a small number of dedicated articles were found: 25 in English (1 on AI, 3 on IoT, 6 on BD, and 15 on CloudCom) and 4 in Chinese (1 on AI and 3 on BD), and an extended search for "right to know", a concept close to accountability, returned no hits. As Figure 5 shows, PISs technology and accountability are both topics that the academia is keen about and despite the small numbers of articles, the relationship between the development of technology and accountability tends to be positive, i.e., the number of articles regarding the intersection of accountability and a particular technology increases along with the increase of the number of articles regarding the technology. This demonstrates that there is increased attention paid to technology accountability.

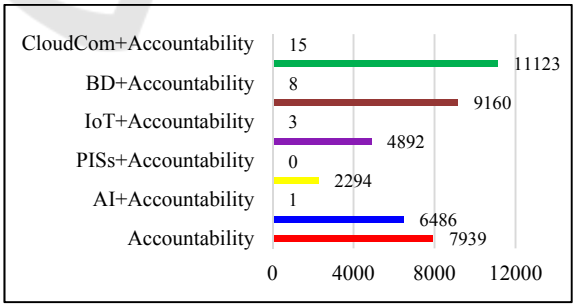

Figure 5: Development of PISs Technologies and Their Relationships with Accountability.

From reviewing those dedicated articles and the relevant ones cited by them, the following observations can be generated:

- Discussions on accountability in relation to advanced technology started with AI in 2001

and kept accelerating with the other components in particular cloud computing;

- Most of the articles take the viewpoint of IT (i.e., authored by IT professionals), and they focus mainly on data privacy (Xhafa et al., 2015; Grunwell and Sahama, 2015) and user accountability, i.e., how users or employees can be accountable for their actions (Boos, et al., 2013; Gao and Iwane, 2015; Khan et al., 2016) (labelled in this application as individual accountability);

- Others are mainly authored by sociology and legal experts, which focus on both the concept itself and its application to technologies (6, 2010; Vedder and Naudts, 2017) (labelled in this application as organizational accountability);

- Information is not the focus of study, albeit it appeared inevitably (e.g., Weber, 2011; Boos, et al., 2013);

- There are three main consensuses:

    - The complexity of the issue (e.g., Ko et al., 2011; Gao and Iwane, 2015);

    - The need for accountability to be addressed at the early stage of technology development (e.g., Boos, et al., 2013; Arnaboldi et al., 2017); and

    - The need for further research as many of the technologies are new or being renewed (e.g., Arnaboldi et al. 2017).

For the four Chinese articles, only two qualify as research articles. Neither of them identified the meaning of accountability within their respective research frames and both promoted technological means for accountability insurance. Differences lie mainly on the level of technological details, with the one on online media suggesting not just people but also technologies are needed to be held accountable in a general manner (Jiang and Yang, 2016) and the other on privacy protection outlining an accountability strategy (Zhu et al., 2016). The core of the strategy, however, targets only the action of malicious leaking of user information on the part of service providers, which does not correspond to the proposed research in that:

- The concept of PISs Controlling Organization has a much broader coverage than service providers;

- For a particular PISs Controlling Organization, the entirety of its decision-making activities is under investigation – not just the action of malicious leaking of user information. To protect user information from breach or leaking is readily distinguishable from the unjustifiable use of personal information in normal business operations.

There are research institutions internationally concerning PISs technologies in relation to transparency and accountability. For example:

- United States: Brookings Institution (technology, accountability and international law); Data and Society (social and cultural issues arising from data-centric and automated technologies);

- United Kingdom: Open Data Institute (data identification of economic evidence and business cases combined with social and environmental impacts);

- United Kingdom and Germany: Information Innovation Lab (development of fundamental rights of communities everywhere around the world);

- Canada: The Citizen Lab ("Lifting the lid off the Internet"; intersection of information and communication technologies, accountability mechanisms, and global security)

- Australia: Smart Cities Research Institute (the grand challenges facing large, fast-growing cities in Australia and around the world; new methods of accountability and feedback);

- The Information Accountability Foundation with Americas Interest Group, Asia Discussion Group, EU GDPR Group (data protection law and practice through accountability-based information governance).

The EU General Data Protection Regulation (GDPR) (Regulation (EU) 2016/679) has included accountability principles in its personal data protection framework. All these efforts, however, focus typically on one aspect albeit with much depth. As the same as what is displayed in Figure 5, the interplay between accountability and PISs as a whole

remains currently a gap. The produced balancing theories and mechanisms therefore aim at

- The realization of a healthy, fulfilling society, one that cares about everyone with equality, promotes economic prosperity with fairness, and materializes democracy in real life events;
- The optimization of corporations' practice of social and ethic responsibility;
- The advancement of disciplinary, interdisciplinary (i.e., integrating knowledge from different disciplines) and transdisciplinary (i.e., creating a unity of intellectual frameworks beyond the disciplinary perspectives) knowledge, as well as the joint process of knowledge production; and
- The preparation of the next generation that is PISs accountability ready.

4 RESEARCH QUESTIONS

The following research questions are identified as key to the identified technology accountability issue, and they are grouped as theory-related and mechanism-related. For the theory-related group, two sub-groups are further developed as theory deductive type and theory inductive type.

Theory- related: Deductive:

- To what extent can the existent accountability theories in the field of public accountability be instructive to the technology accountability issue? e.g., principal-agent theory (Gailmard, 2007)? Contingency theory (Mansbridge, 2014)?.
- Given the established relationship between information and accountability (Stewart, 1984; Parkinson, 1993; GC, 2007; Obama, 2009; United Kingdom, 2009; NAA, 2017), what kind of application of the current development of computational archival science and digital records management (CAS and DRM) are suitable for building technology accountability solutions?

Theory- related: Inductive:

- In the context of equal social and economic development, what the considerations or criteria should be for the properness of balance between accountability and PISs be determined?
- Among the different types of balancing forces (i.e., PISs H-Agent type of decision recipients, in forms of individual and aggregations), what are the relationships between them? And what kind of relationships can facilitate a positive impact on developing PISs balancing power?
- What should the responsibility relationships be among all the entities in Figure 4?
- What will the PISs synergetic effect be when compared to the impact of individual PISs technologies on accountability?
- Will the relationship between PISs deployment and PISs accountability remain the same across industries or it will change? If it will change, then what the most influential factors for the change are?

Mechanism - related:

- How can accountability information be identified for a particular decision? How to decide its ownership? When should the identification take place? At the time of deploying PISs? At the time of receiving accountability inquiries? Or automatically when a decision is made?
- How can accountability information for a particular decision be delivered? When should the delivery take place? At the time of receiving accountability inquiries? Or automatically when accountability information is identified?
- How can the answerability of accountable information be ensured?
- How can the discharge of responsibilities be evaluated?
- Can PISs technologies be used to automate the responding process to accountability inquires?

5 RESEARCH DESIGN

For investigating the above research questions, two research methodologies were selected: design science research (DSR) and grounded theory methodology (GTM). Both methods have been promoted to be employed in ISs (Gregor and Hevner, 2013; Wiesche et al., 2017) and their investigating courses are illustrated in Figures 6 and 7.

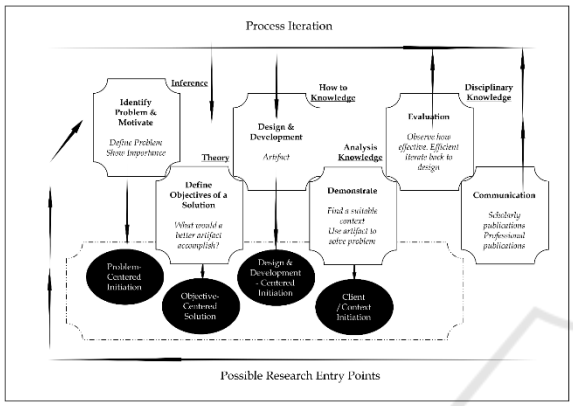

Figure 6: Design Science Research Methodology Process Model (Peffers, et al., 2008).

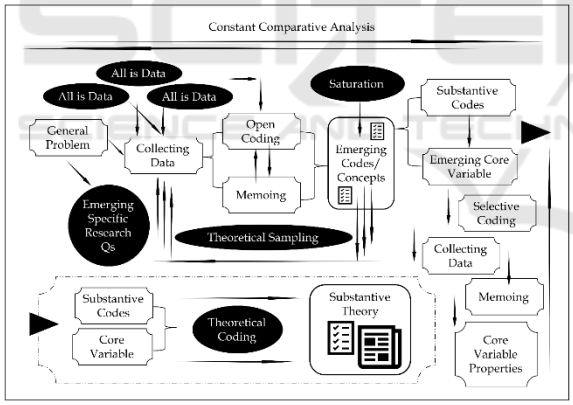

Figure 7: Grounded Theory Methodology Process Model.

For the proposed research, DRS is responsible for answering the research questions of the theory deductive type and of the mechanism-related, and GTM is responsible for answering the research questions of theory inductive type. Data for both methods include the types of published research, which, as displayed in Figure 5, is sizable by now and is constantly growing, and empirically collected data, which will be done by the tools of questionnaires and interviews. By integrating these two methods, balancing theories and mechanism to PISs are expected to be produced. Figure 8 displays the overall process of the research:

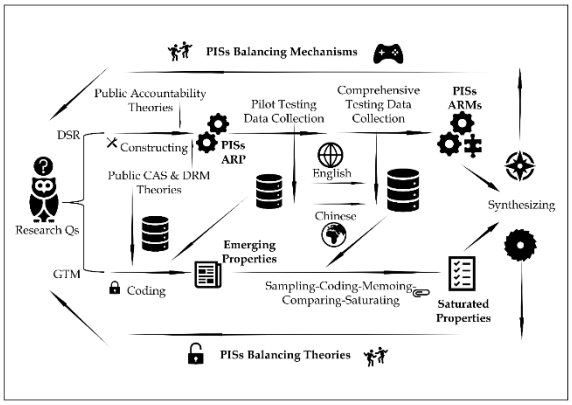

Figure 8: PISs Balancing Theories and Mechanisms Research Process.

6 A CALL FOR RESEARCH COLLABORATIONS

The proposed research is considered leading internationally in the following three aspects:

- Focusing on the impact of integrated PISs instead of just that of PISs component technologies (Figure 2);
- Findings to be instructive to the development of standards by ISO, who is currently at the initiating stage of developing relevant standards (Figure 9);
- Enhancing the understanding and application of PISs to the fields of social science and humanities (Figure 10).

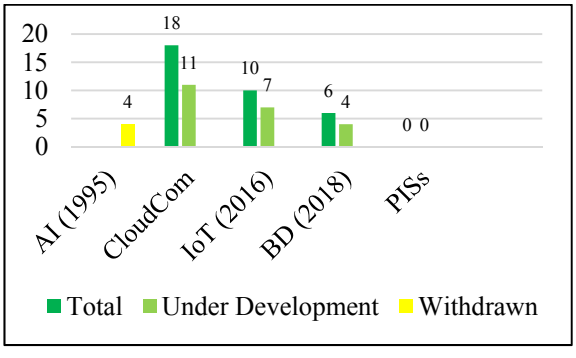

Figure 9: ISO Standards Re PISs Component Technologies Currently Under Development.

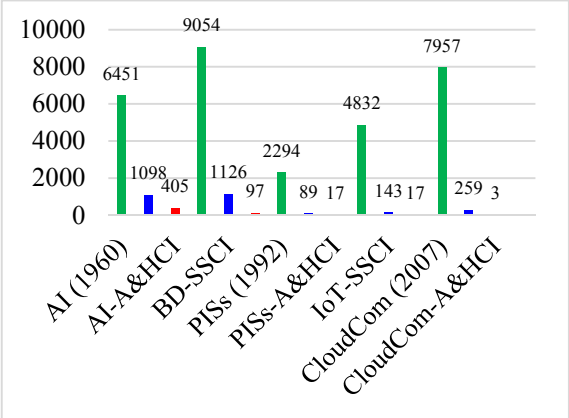

Figure 10: Current Situation of PISs Applications to fields of Social Science and Humanities.

The proposal to timely investigate PISs accountability takes into also the consideration that many governments are investing massively in PISs technologies. It is an international consensus that these technologies are critical to the enhancement of all-around national competitiveness; consequently, the past couple of years see increasingly the establishment of notional policies that strongly encourage the racing for advancements of PISs technologies. Enthusiasm, however, cannot be the only condition for success. Comprehensive planning including careful examination of side affects (or trade-offs) must be part of this technology development movement.

Accountability is a societal necessity because it represents the force that aims to counter the controlling power of decision-making authorities. As such, it is widely acknowledged in both the organizational types of government institutions and business corporations. For government institutions, accountability requires the provision of information regarding the policies they make (Peters, 2014) and for business corporations, the promotion of self-discipline and code of conduct (Pava, 2008; Thorne, 2008). These accountabilities, however, do not represent sufficiently digital decision accountability, or in general, technology accountability. In a PISs environment, digital decisions are being made constantly and they are made by technologies that are ubiquitous and invisible. These features and their combined effects make it extremely difficult for accountability information to be available and/or with answerability. As a consequence, human decision recipients, also the typical accountability force, will find it extremely difficult to make inquiries about the decision-making processes, let alone to understand them. For example, in-memory processing offers instant analytical results, however, re-examination of the results in a later time will have to take much more time because the participating data threads are moved to permanent storage media after the in-time processing and delivery. Re-examination may not even be at all possible if the participating data threads are not considered worthy being retained in permeant storage media. The promise of context-aware computing is to tailor information products and services to user needs as much as possible, and with the help of IoT and BD analytic thinking, such promise is speedily becoming a reality. To reconstruct the tailoring process, however, can be time consuming or entirely impossible, depending on the degree of customization, i.e., the combination of the number of data threads used as input, the formats in which these data threads existed, and the complexity of the analytical tools utilized. It must be pointed out that these examples describe only challenges caused by individual use of technologies, not the pervasiveness of computing as framed in PISs. As stated above, in true PISs, all decisions, big or small, are made based on ubiquitous technologies that are invisible to the consumers of information, meaning that even the decision makers do not know where the information prompted in front of them come from and how it is produced, let alone the recipient of the decisions. These difficulties accumulate with the increased number of digital decisions and the level of integration between PISs H-Agent and PISs D-Agent and are compounded with the fact that accountability inquires typically take place at times (much) later than that of decision making.

If decision-making processes cannot be sufficiently understood by decision recipients, decisions will be impossible to be challenged, and with the current situation where decision-making powers are increasingly concentrated in the hands of PISs technology companies, the needed balance between decision makers and decision recipients will be in peril and may eventually be lost. Decision-making powers must be justly countered as a healthy, harmonized society is one that is properly balanced. With such balance comes along stability, yet, without such balance, common interests can never be identified, prosperity can hardly be sustained and the danger of digital technology dictatorship looms. If we are not ready to trust blindly digital decisions, if we indeed fear to have to live in a “black box” empowered society (Pasquale, 2015), and if we do believe there are “weapons of math destruction” (O'Neil, 2016), the interplays between PISs and accountability must be investigated. Among the many

examples, the Facebook scandal is telling us live: digital decisions and the person(s) behind these decisions can be invisible even to a PISs organization itself and manipulations of user-generated data can be unlimited. It is time for us ordinary people, the data supplier, to be united, to take actions, and to make the invisible visible. To that end, we need collaborations from all fellow enthusiasts.

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