

Refereed Paper Proceedings

KM2023 Conference Sponsoring Schools and Organizations:









KM2023 Conference Partner Organization:





Table of Contents

Conference Chairs, Organizers, OJAKM Editorial Board Leadership, and Program Committee

1-5

Identification of participants in business process modeling using BPMN Przemysław Polak *6-15*

Framework for trusted and fair data sharing and use Emmanuel Kellner *16-27*

Internet of things and smart technologies in oral health: A systematic mapping study

Susana J. Calderon Stephen Mujeye 28-39

A gap analysis of knowledge management performance using a State Enterprise Assessment Model (SE-AM): A case study of a Thai airport operator Kom Campiranon 40-49



Conference Chairs, Organizers, OJAKM Editorial Board Leadership, and Program Committee

KM2023 Conference Co-Chairs





Jean-Henry MorinChristiaan MaasdUniversity of Geneva,Stellenbosch UnivSwitzerlandSouth AfricaJean-Henry.Morin@unige.chchm2@sun.ac.za

Christiaan MaasdorpRoStellenbosch University,FOSouth AfricaSychm2@sun ac zary



Rolf von Rössing FORFA Consulting AG, Switzerland rvr@forfa.ch

KM2023 Conference Organizers and Coordinators





Yair Levy Nova Southeastern University, FL, USA <u>levyy@nova.edu</u>

IIAKM, USA registration@iiakm.org

KM2023 Conference Workshops Co-Chairs



Celina Sołek-Borowska Warsaw School of Economics, Poland csolek@sgh.waw.pl



Michelle M. Ramim Nova Southeastern University, USA <u>michelle.ramim@gmail.com</u>



Nathan White Central Washington University, USA <u>nathan.white@cwu.edu</u>



Julita Haber Fordham University, USA jhaber7@fordham.edu



Online Journal of Applied Knowledge Management (OJAKM) – Editorial Board Leadership



Meir Russ – *Editor-in-Chief*

University of Wisconsin - Green Bay, USA

<u>russm@uwgb.edu</u>



Carla Curado *OJAKM Associate Editor* ISEG - University of Lisbon, Portugal ccurado@iseg.ulisboa.pt



Nitza Geri

Israel. Israel

Editor

OJAKM Associate

The Open University of

nitzage@openu.ac.il

Aino Kianto – *OJAKM Senior Editor* LUT School of Business and Management, Finland <u>Aino.Kianto@lut.fi</u>



Yair Levy – *itor OJAKM Senior Editor* Nova Southeastern University, FL, USA

levyy@nova.edu



Oliver Jokisch OJAKM Associate Editor

HSF University of Meissen, Germany oliver.jokisch@hsf.sachsen.de



Ewa Ziemba – *OJAKM Senior Editor*

University of Economics in Katowice, Poland

ewa.ziemba@ue.katowice.pl



Federico Niccolini – OJAKM Associate Editor

University of Pisa, Italy federico.niccolini@unipi.it

KM2023 Program Committee Co-Chairs



Melissa Carlton Lindsey Wilson College, USA

carltonm@lindsey.edu





Molly Cooper

Ferris State University, USA

MollyCooper@ferris.edu

KM2023 Program Committee Members

Emily Africk	University of Michigan, USA
Amy Antonucci	Western Governors University, USA
Graziano Aretusi	Marine Protected Area Torre del Cerrano, Italy
Gunnar Auth	HSF University of Applied Sciences, Germany
Patricia Baker	CoreLogic Inc, USA
Michael Bartolacci	Penn State University, USA
Dizza Beimel	Ruppin Academic Center, Israel
Ofir Ben Assuli	Ono Academic College, Israel
Igor Bernik	Faculty of Criminal Justice and Security (FVV), Slovenia

University of Wisconsin -

Green Bay, USA russm@uwgb.edu



Brian Bisceglia Carlene Blackwood Brown Sara Blasco Romám Ina Blau **Benny Bornfeld** Marko Bohanec Celina Solek-Borowska Steve Bronsburg **Brian Buckles** Kom Campiranon Melissa Carlton Jonathan Choukroun Dimitar Christozov Karla Clarke **Christopher Collins** Molly Cooper Carla Curado Gabriel Corneio Dipankar Dasgupta John Del Vecchio **Bostjan Delak** Sandra Dettmer Horatiu Dragomirescu Patryk Dziurski **Darrell Eilts** Monika Eisenbardt Jerry Emerick Tamer Fahmy Beth Ferrigno Steven Furnell Ruti Gafni Nitza Geri Greg Gogolin **Tiago Goncalves** Jose Luis Guerrero Cusumano Julita Haber Zadok Hakim

Nova Southeastern University, USA Seneca College, Canada Copenhagen Business School, Denmark The Open University of Israel, Israel Ruppin Academic Center, Israel Jožef Stefan Institute, Slovenia Warsaw School of Economics, Poland Nova Southeastern University, USA National Defense University, USA Thammasat University, Thailand Lindsey Wilson College, USA Baptist Health, USA American University of Bulgaria, Bulgaria California State University San Bernardino, USA Nova Southeastern University, USA Ferris State University, USA ISEG - University of Lisbon, Portugal DoD. USA The University of Memphis, USA Nova Southeastern University, USA Faculty of information studies, Novo Mesto, Slovenia Swansea University, United Kingdom Bucharest University of Economic Studies, Romania Wroclaw University of Economics, Poland Loyola University New Orleans, USA University of Economics in Katowice, Poland Ferris State University, USA Meta. Ireland Franklin University, USA University of Nottingham, UK Tel-Aviv Yaffo Academic College, Israel The Open University of Israel, Israel Ferris State University, USA Universidade de Lisboa - ISEG, Portugal Georgetown University, USA Fordham University, USA The University of the Cumberlands, USA



Tsipi Heart Wilnelia Hernandez Robert Hoyt Angel Hueca Pedro Isaias Emmanuel Jigo Oliver Jokisch Emmanuel Kellner Dan Kohen Vacs Anne Kohnke Gila Kurtz Gregory Laidlaw Yair Levy Wei Li Ariel Luna Christiaan Maasdorp Juan M. Madrid Joe Marnell Herbert Mattord Saw Sandi Maung John McConnell Eliel Melon Anže Mihelič Stephen Mujeye **Roisin Mullins** Martina Neri Federico Niccolini Michael Nowatkowski Sergio Nunes Jose Ortiz Tal Pavel Przemyslaw Polak **Tommy Pollock** Ashraf Qutaishat Daphne Raban Michelle Ramim Meir Russ

Ono Academic College, Israel WH-Consulting, Puerto Rico Virginia Commonwealth University, USA Carnegie Mellon University/CERT, USA University of New South Wales (UNSW - Sydney), Australia JiSec, USA HSF University of Meissen, Germany Logair, Switzerland Holon Institute of Technology, Israel University of Detroit Mercy, USA HIT - Holon Institute of Technology, Israel University of Detroit Mercy, USA Nova Southeastern University, USA Nova Southeastern University, USA Nova Southeastern University, USA Stellenbosch University, South Africa Universidad Icesi, Colombia Wayland Baptist University, USA Kennesaw State University, USA University of Pannonia, Hungary Johns Hopkins Health System, USA University of Puerto Rico, Puerto Rico University of Maribor, Slovenia Illinois State University, USA University of Wales Trinity Saint David, UK University of Pisa, Italy University of Pisa, Italy Augusta University, USA ISEG - University of Lisbon, Portugal University of Puerto Rico, Puerto Rico The Academic College of Tel Aviv-Yaffo, Israel Warsaw School of Economics, Poland Tidewater Comm. College and National Defense University, USA University of Minho, Portugal University of Haifa, Israel Nova Southeastern University, USA University of Wisconsin - Green Bay, USA



Nanette Saes	Stellenbosch University, South Africa
Joanna Santiago	ISEG - University of Lisbon, Portugal
Dara Schniederjans	University of Rhode Island, USA
Tamar Shamir-Inbal	The Open University of Israel, Israel
Christopher Shear	Stellenbosch University, South Africa
Sofia Sherman	The Academic College Tel Aviv Yaffo, Israel
Given Shingange	Stellenbosch University, South Africa
Ingo Siegert	Otto von Guericke University, Germany
Vered Silber-Varod	The Open University of Israel, Israel
Yamini Sinha	OVGU Magdeburg, Germany
Martha Snyder	Nova Southeastern University, USA
Sitthimet Solthong	Bangkok University, Thailand
Celina Sołek-Borowska	Warsaw School of Economics, Poland
K. Subramani	West Virginia University, USA
Mathupayas Thongmak	Thammasat Universit, Thailand
Michael Tu	Purdue University Northwest, USA
Tomasz Waliczko	Technische Universität Berlin, Germany
Ling Wang	Nova Southeastern University, USA
Bruce Watson	Stellenbosch University, South Africa
Knut Ingar Westeren	Nord University, Norway
Nathan White	Central Washington University, USA
Jędrzej Wieczorkowski	Warsaw School of Economics, Poland
Darren Wiggins	Nova Southeastern University, USA
Amir Winer	The Open University of Israel, Israel
Brigitte Wodrich	Nova Southeastern University, USA
David Zeichick	California State University (CSU), Chico, USA
Yuting Zhang	Boston University, USA
Ewa Ziemba	University of Economics in Katowice, Poland
Rina Zviel-Girshin	Ruppin Academic Center, Israel

We would like to thank all the Program Committee (PC) members for their outstanding scholarly reviews and dedicated feedback to the authors!



Identification of participants in business process modeling using BPMN

[Research-in-Progress]

Przemysław Polak, Warsaw School of Economics, Poland, ppolak@sgh.waw.pl

Abstract

Business Process Model and Notation (BPMN) is one of the most complex languages used in business process modeling and in the graphical presentation of functional requirements of Information Technology (IT) systems. The use of some elements of the notation in practice is controversial and often does not comply with the provisions contained in the standard. This situation can lead to ambiguity in the documentation of business processes. One of such difficult concepts are the participants of the business process. The purpose of this article is to identify problems related to participant identification and the use of pools in modeling with the use of BPMN, as well as to determine the reasons for this situation.

Keywords: Business process management, information systems, business analysis, business process modeling, business process participants, BPMN.

Introduction

According to the principles of business process management, an organization must describe all its business processes and provide access to diagrams showing the flow of these processes for all employees of the organization. Thanks to that, the knowledge about the way the organization works is disseminated to every employee. Every staff member can understand his role in the organization and, thanks to that knowledge, he can initiate changes beneficial to the entire institution.

Business Process Model and Notation (BPMN) is a language used both in business process management as well as in business analysis and system analysis to specify the requirements for an Information Technology (IT) system. The current version 2.0.2 was published in 2013 (OMG, 2003). In addition to identifying elements related to determining the structure and sequence of a business process, BPMN also allows to present on a diagram the participants of business processes. Author's observations both as an academic teacher in the field of management information systems and modeling of IT systems, with particular emphasis on process modeling, and author's practical experience in work of a business and system analyst gave an opportunity to familiarize himself with the documentation created both as part of business process management and with IT systems documentation. This allowed the author to notice different approaches and errors in the use of pools in BPMN, as well as inconsistencies with the definition of these objects in the standard.



This is a very serious problem, because the most important desirable features of the documentation created in business process modeling are unambiguity and identical interpretation by all stakeholders, both at the time of creating the solution and when referring to the documentation later. These features should be preserved by unambiguous and correct referring to the definition of the BPMN standard.

The author's observations indicate that a fairly common problem is the use of a pool in a manner inconsistent with the definition of the standard. Therefore, the author made an attempt to identify and classify problems with the use of pools in BPMN, as well as an attempt to identify the causes of this situation. For this purpose, the article analyzes the participant and pool definitions in the BPMN standard documentation, as well as in the most popular literature on business process modeling in BPMN. Both the literature addressed to IT specialists using notation to specify requirements for IT systems and the literature on business process modeling in the broadly understood business process management were taken into account. Based on the literature and the author's observations of documentation created as part of commercial projects, potential causes of this situation were identified. This analysis led to the hypothesis that the background and orientation of the modeler toward business process management or towards IT systems affects the style of business process modeling. Then, an experiment was conducted to verify the correctness of the identification of the causes. Students specializing in business analysis took part in the experiment. Therefore, the research methodology used in this study includes the author's observations, a literature review, and an experiment.

Literature Review

Although the literature on the correctness of modeling using BPMN is extensive, it does not include the discussion of participant and pool identification. In the first place, the correctness of modeling using BPMN is dealt with in publications in the form of textbooks and guidelines. However, such publications do not contain the study of this phenomenon, but only provide patterns or indicate possible incorrect constructions used in modeling. Avila et al. (2020) conducted a comprehensive literature review of process modeling guidelines.

Already at an early stage of research into the use of the BPMN 2.0 standard, Allweyer (2012) noticed that the individual style of modeling can strongly affect the clarity of process maps. Some observations suggest that analysts with IT background tend to create complex, very detailed diagrams that can affect the clarity of diagrams for other users, and interfere with one of the cornerstones of the process approach – the ability to easily understand and analyze processes by all users within an organization (Polak, 2013).

Leopold et al. (2015) conducted a qualitative study of process models created with BPMN. The study covered models from six companies. The authors of that publication focused primarily on errors in the logic of processes and the consistency of entire models. However, they did not discuss the elements not included in the process sequence flow. Haisjackl et al. (2015) research on quality issues in BPMN models concerned pools and lanes only in the context of their use by humans



inspecting the quality of business processes. They did not take into account the possibility of misuse of pools and lanes. Also, the taxonomy of business process model anti-patterns proposed by Koschmider et al. (2019) did not take into account participants and pools.

Participants and Pools in BPMN

The concept of a pool does not occur in older popular business process modeling languages such as Event-driven. Process Chain (EPC) included in the Architecture of Integrated Information Systems (ARIS) architecture (Scheer et al., 2005) and BPMS developed as part of the popular Adonis business process modeling tool (BOC Group, 2006; Junginger et al., 2000). However, the concept of a swimlane representing the organizational unit responsible for performing functions is commonly used in these notations or their enhancements (Legner & Wende, 2007). BPMN introduced a separate concept of a pool that represents a participant in a business process. The emergence of the pool resulted from the introduction of the concept of collaboration in BPMN. Graphically, the pool is a container for a process, separating it from other processes (OMG, 2003, p. 501). The participant is a business concept and represents either a business partner or an external role (OMG, 2003, p. 113). A lane is a sub-partition within a process (often within a pool). The standard only specifies that lanes serve to categorize and organize activities. The meaning of the lanes is up to the modeler. Lanes are usually used for representing internal departments, internal roles, and software applications (OMG, 2003, pp. 304-305). Unfortunately, the BPMN standard also uses the term swimlane which it defines as a graphical container for partitioning a set of activities from other activities, and it distinguishes two types of swimlanes: pools and lanes (OMG, 2003, p. 502). However, the standard discusses pools and lanes in detail separately. Nevertheless, the use of this term can be confusing because some people can equate the terms swimlane and lane. This is the case with other notations. The authors of some textbooks on BPMN, e.g. Allweyer (2010, p. 16) limit the role of a pool to the container for a process. It leads to labeling a pool with the name of a process, which is inconsistent with the standard. Silver (2011, p. 20) takes a middle ground between Allweyer (2010) and the BPMN standard (OMG, 2013), allowing pools to be labeled by the name of an organization as well as the name of a process. Silver (2011, p. 20) also suggests that lane is the BPMN term for swimlane. Debevoise and Taylor (2015, p. 41) agree that a pool represents a participant and contains the elements of a process flow performed by a participant. However, they claim that a participant is an actor or a person who interacts with a process, and in effect, a participant can be a human, a system, a machine, another process, a position or a role in an organization, a group of people, and a group of systems. Given examples of participants include an employee filling out a form, a database server, a web service, an application server (Debevoise & Taylor, 2015, p. 42). This approach is completely inconsistent with the BPMN standard.

Freund and Rücker (2014) treated the use of pools and lanes most freely. They allow practically all constructions discussed by other authors. In some cases, they allow the same objects to be presented interchangeably as pools or lanes (Freund & Rücker, 2014, p. 72). Dumas et al. (2018, p. 97) recommend using pools to model business parties like a whole organization, and lanes to



represent departments, units, teams, software systems, or equipment within an organization. They also use the concept of internal and external participants (Dumas et al. (2018, p. 4). This division corresponds to the suggested usage of pools and lanes in the documentation of the BPMN standard. Even a fairly small review of BPMN textbooks limited to just a few of the most popular items showed how different approaches to the use of the concept of a pool in diagrams can be. It is worth noting that the most explicit way of using pools and lanes was proposed in a publication not directly related to BPMN, but presenting broadly understood issues of business process management (Dumas et al., 2018). What is important, the proposed approach is consistent with the provisions of the BPMN standard.

Identification of Problems with the Use of Pools in BPMN

The reference point for assessing the correctness of the use of pools in BPMN is the content of the document describing the BPMN standard (OMG, 2013). Among the other publications presented above, the most consistent and at the same time compliant with the provisions of the standard, although narrowing down the ways of using lanes, are the recommendations presented in the publication on business process management (Dumas et al., 2018). Observations of documentation of business processes created as part of process management and identification of requirements for IT systems, to which the author had access as part of his work as a business analyst and system analyst, allowed the author to identify the three most common cases of incorrect use of pools in BPMN. The first and the most common type of error is presenting the organization's departments, internal roles, or positions as separate pools. In particular cases, such a division is justified by the high independence of a department from other parts of an organization. The functions of such a department can often be outsourced to an external company. In such cases, it is not considered an error, but such a situation does not apply to the following experiment.



Figure 1. Example of an IT system represented as a pool



The second misuse of pools concerns the representation of an IT system as a separate pool (see Figure 1). In some cases, there were several such pools on a diagram, each representing an individual software application. The author also noted multiple cases of the unjustified representation of a software application as a lane (see Figure 2). However, this is a matter of individual assessment because the standard accepts such solutions. Therefore, such cases cannot be always considered incorrect. But the most common and correct method of showing that a task is performed by an IT system is to choose a proper task type, for example, a user task (see Figure 3).



Figure 3. Example of a task executed by an IT system

The third type of error is of a different nature than the others. The first two types refer to the situation when internal objects of an organization are presented as separate pools. The third type is the case when external participants or external roles are represented in diagrams as lanes. In this case, it may also be about completely ignoring pools and using only lanes in business processes modeling. In the author's opinion, the first type of error often occurred in documentation related to business process management, for example, when modeling processes for the purposes of obtaining ISO 9000 series quality management certificates. The second error occurred much more often in documentation created as part of the projects aimed at implementing IT systems. This type



of documentation is usually created by requirement engineers and system analysts, i.e. people strongly associated with IT. The third type of error occurs relatively less often, and based on the documents available to the author, it cannot be associated with the specific type of process documentation.

Organization of the Experiment

The aim of the experiment was to verify whether the background and orientation of the modeler toward business process management or towards IT systems can affect the style of business process modeling, and in this particular case, the way pools and tracks were used. The participants of the experiment were students of postgraduate diploma courses in the field of business analysis conducted at an institution. This course is a specialized one-year program combining academic classes with practical training conducted by experts in their field. The course is addressed to people working in both IT and various areas of management who intend to extend their competencies in the area of business analysis, as well as those already working as business analysts who intend to expand their competencies. The experiment was carried out as part of normal classes and the participants were not aware of their participation in the experiment because they solved typical inclass case studies, and their solutions were available to the lecturer who was the author of this article. That approach helped participants to act naturally and not be biased. The consequence of that method was the situation that it was not possible to link the analyzed case study solutions to specific persons and to any information about them, as that would violate the provisions on the protection of personal data and privacy. The duration of the experiment was extended for over a year, which allowed it to conduct with the participation of 109 students of three editions of postgraduate courses. As part of business process modeling classes, students were divided into groups of up to twenty people. Thanks to this, each edition of the course included two subgroups, and in each of them, it was possible to carry out a different version of the case study. In total, 109 participants took part in the experiment, 55 participants in the first group and 54 participants in the second group. Participants were randomly assigned to groups based on the alphabetical order of the students' surnames. Thus, when dividing into groups, the background experience of the participants was not taken into account.

Before the experiment, during an introductory lecture on the BPMN, the basic principles of modeling were presented, including the definitions of the concepts of the basin, the participant and the lane, all according to the rules presented in the BPMN standard. However, typical problems related to the use of these elements in practice were not discussed at that time. That discussion took place only after analyzing the case study solutions presented by the students. The experiment took place four weeks after the lecture.

During the experiment, students in both groups received case studies describing the same business process. However, the texts of the case studies differed in detail. In the first case, the terms IT system, software application and the like were never used. Only activities in the business process were described, including internal participants: organizational units and roles. External



participants were also listed: a customer and a bank that executes a payment. The group that received this version of the case will be referred to as the business group in the following sections of this article. On the other hand, the case study for the second group contained references to IT systems and computer applications in the description of some activities of the business process. This group will hereinafter be referred to as the IT group. In this way, in the first group, the perception of the business process by people involved in business process management was simulated. In the second version, the description of the case study suggested the point of view of IT specialists.

The Results of the Experiment

Case study solutions submitted by students were searched by the author for the occurrence of four constructs:

- 1. Representations of an internal unit or internal role as a pool.
- 2. Representations of an internal IT system as a pool.
- 3. Representations of an external participant as a lane
- 4. Representations of an internal IT system as a lane.

It should be emphasized that the fourth construction is not incorrect taking into account only the provisions in the standard. However, in the discussed case study, the use of this construction is unjustified. There is no reasonable need for the software applications used in the process to be represented as lanes.

The percentage share of students' solutions containing the four discussed structures in the business group and in the IT group is presented in Table 1.

The type of the incorrect construct	Percentage of occurrences in the business group	Percentage of occurrences in the IT group
1. An internal unit or internal role as a pool	9.1 %	3.7 %
2. An internal IT system as a pool	1.8 %	7.4 %
3. An external participant or external role as a lane	1.8 %	0 %
4. An internal IT system as a lane	3.6 %	16.7 %
Total	16.4%	27.8%

Table 1. The percentage of solutions containing the incorrect structures in the experiment



The percentage of incorrect use of pools (types 1 and 2 in Table 1) is very similar in both groups: 10.9% in the business group, 11.1% in the IT group. But in the IT group, software applications were more often represented as pools. Representing IT systems as lanes was also significantly more popular in the IT group. A total of 24.1% of solutions from the IT group included constructs representing IT systems on process diagrams, compared to only 5.4% in the business group. The number of pools representing internal participants was higher in the solutions from the business group. But in the IT-oriented group, this error has been transferred to showing software applications as pools.

In general, the number of incorrect constructs in the IT group (27.8%) was clearly higher than in the business group (16.4%). It should be noted, however, that representing IT systems as lanes is not an error from the BPMN standard's point of view. Taking this into account, it can be assumed that the number of fundamental errors in the IT group (11.1%) was lower than in the business group. The results clearly indicate that the presence of IT concepts (such as software applications or IT systems) in the case study text resulted in increased usage of constructs that represent IT systems as pools or lanes on BPMN diagrams.

Summary

The results of the experiment are consistent with the described above observations of actual business process documentation. The background of person modeling processes using BPMN influences the way processes are modeled in terms of the use of pools and lanes. The incorrect representation of internal units and roles appears more often in the documentation related to business process management created by process-oriented specialists. Whereas, the incorrect representation of IT systems and software applications is associated with models created by personnel with IT backgrounds.

The research presented in the article was based on the limited number of observations made by the author of the article, as well as on the basis of the experiment simulating only the background and behavior of the participants. The limited scope of the study requires extending it to a larger number of participants with well-identified previous experience in IT and business process modeling. An ideal form of research would be the possibility of evaluating more documentation of business processes made as part of projects implemented in practice and coming from various sources. At the same time, it would be beneficial to identify the background of the authors of the documentation. This type of research can be very difficult to carry out for organizational limits and for the protection of the intellectual value of involved organizations. However, such a method would ensure the high level of quality of results.

References

Allweyer, T. (2010). *BPMN 2.0: Introduction to the standard for business process modeling.* Norderstedt: Herstellung und Verlag, Books on Demand.



- Allweyer, T. (2012). Human-Readable BPMN Diagrams. In L. Fischer (Ed.), *BPMN 2.0* handbook: Second edition: methods, concepts, case studies and standards in business process modeling notation (*BPMN*) (pp. 193-208). Future Strategies Inc.
- Avila, D. T., dos Santos, R. I., Mendling, J., & Thom, L. H. (2020). A systematic literature review of process modeling guidelines and their empirical support. *Business Process Management Journal*, 27(1), 1-23.
- BOC Group (2006). Method manual, BPMS method. In: Adonis Version 3.9, Volume 3.
- Debevoise, T., Taylor, J. (2014). *The micro guide to process and decision modeling in BPMN/DMN*. Lexington, VA: Advanced Component Research.
- Dumas, M., La Rosa, M., Mendling, J., Reijers, H. A., (2018). Fundamentals of business process management: Second edition. Berlin: Springer-Verlag.
- Freund, J., & Rücker, B. (2014). *Real-life BPMN. Using BPMN 2.0 to analyze, improve, and automate processes in your company (2nd Ed.).* Camunda.
- Haisjackl, C., Pinggera, J., Soffer, P., Zugal, S., Lim, S. Y., & Weber, B. (2015). Identifying quality issues in BPMN models: An exploratory study. *Proceedings of the Enterprise*, *Business-Process and Information Systems Modeling: 16th International Conference*, *BPMDS 2015, 20th International Conference, EMMSAD 2015, CAiSE 2015, Stockholm*, *Sweden, June 8-9, 2015* (pp. 217-230). Springer International Publishing.
- Junginger, S., Kühn, H., Strobl, R., & Karagiannis, D. (2000). A business process management tool of the next generation - ADONIS: conception and applications. *Business Informatics*, 42(5), 392-401.
- Koschmider, A., Laue, R., & Fellmann, M. (2019). Business process model anti-patterns: A bibliography and taxonomy of published work. *Proceedings of the 27th European Conference on Information Systems (ECIS)*. Stockholm-Uppsala.
- Legner, C., & Wende, K. (2007). The Challenges of inter-organizational business process design: A research agenda. *Proceedings of the 15th European Conference on Information Systems* (ECIS 2007) (pp. 1643-1654).
- Leopold, H., Mendling, J., & Günther, O. (2015). Learning from quality issues of BPMN models from industry. *IEEE software*, *33*(4), 26-33.
- OMG (2013). Business Process Model and Notation (BPMN) Version 2.0.2. Object Management Group.
- Polak, P. (2013). BPMN impact on process modeling. *Proceedings of the 2nd International Business and System Conference BSC 2013* (pp. 26-32). Riga: Riga Technical University.
- Scheer, A. W., Thomas, O., & Adam, O. (2005). Process modeling using event-driven process chains. In M.Dumas, W. M.Van der Aalst, & A. H. Ter Hofstede (Eds.) *Process-Aware*



Information Systems: Bridging People and Software through Process Technology (pp. 119-145). John Wiley & Sons.

Silver, B. (2011). BPMN method and style: Second edition: With BPMN implementer's guide. Cody-Cassidy Press.

Author Biography

Przemysław Polak, Ph.D. is a senior lecturer and a director of the Postgraduate Studies in Business Analysis in the Institute of Information Systems and Digital Economy at the Warsaw School of Economics. He is also an independent consultant in the field of information systems.





Framework for trusted and fair data sharing and use

[Research-in-Progress]

Emmanuel Kellner, University of Geneva, Switzerland, emmanuel.kellner@unige.ch

Abstract

Data use, the processing of data for a specific purpose, is a valuable activity across various sectors. The costs and risks linked to collecting data support the generalization of data sharing and reuse, spreading potential benefits and costs among users. Similarly, data use can involve multiple actors and systems, each providing services responsible for some data processing activity. Distribution of data and data uses, as well as evolving legal and technical landscapes, force stakeholders to adapt their practices to new risks. Data exchanges answer fairness, trust, and transparency requirements by providing appropriate services. Distributed data exchanges, then, have participants directly sharing governance rights as they share assets. This distribution can produce resilient and scalable systems offering participants greater control over their assets' lifecycles, but they often forego interoperability. This paper is part of research in progress aimed at exploring how data exchanges based on distributed governance can answer adaptable fairness and trust requirements, enforcing the sharing and use policies defined by participants in ways that preserve conditional interoperability. We propose a tentative model for data exchange systems that can adapt to answer participants' requirements and their regulatory and technological environment.

Keywords: Data sharing, distributed system, data governance, system model, fairness, trust.

Introduction

Data sharing and use of shared data are potential sources of value for the private and public sectors, academia, but also civil society (Custers & Vrabec, 2016; Janssen et al., 2014). Trust and fairness in processes are essential to ensure benefits, as reuse can produce economic, operational, legal, and ethical impacts that are difficult to forecast.

Data governance represents the exercise of authority and control over the management of data (Abraham et al., 2019). It defines information security, quality, and usability principles supporting beneficial data use. A growing number of instruments try to address the governance issues linked with data sharing (Abbas, 2021), but they mostly target privacy risks linked to personal data reuse (Gelhaar & Otto, 2020).

Data exchanges are systems providing appropriate services to support data sharing for reuse. Taxonomies and models for data exchanges describe a diversity of information systems and services implemented (Driessen et al., 2022), with differences in architectures and governance



models. Distributed governance allows stakeholders to better enforce their rights, thus preserving fairness and trust in data reuse. However, systems rigidly built on some use-case requirements might not be interoperable. This paper proposes to explore how data exchanges based on distributed governance can provide the conditions enabling and broadening data sharing and reuse while ensuring fairness, trustworthiness, and accountability. To answer this issue, we propose a model of data exchange that can adapt to answer participants' and regulatory requirements and build on available services to support its functions. This work will help advance the understanding of how data protection principles apply to inter-entity data sharing and potentially lead to a trusted data lifecycle through its instantiation.

Literature Review

Data Sharing for Reuse

Data are pieces of machine-readable information, collected as abstractions of the world, that can be used to derive information, then knowledge, about entities or activities (Kitchin, 2014). Data represent valuable assets supporting the decision-making and optimization (Murdick & Munson, 1986) and enabling the data-driven products and services (Hunke et al., 2020; Rizk et al., 2018). Here, we describe the benefits and risks of data sharing, then expose some principles for data governance.

Data use as an expression of their value

Data are products of human activities that can carry an economic value equivalent to their expected or potential use. The assumption of future benefits is generally sufficient to motivate the data collection (Hunke et al., 2020). The value held by data, however, can only be realized through their use, i.e. their processing for the realization of a specific purpose (Custers & U Vrabec, 2016). The European Union defines data processing as any action involving data, including that of storage or destruction (General Data Protection Regulation, 2016). Any further processing beyond their initial purpose, e.g. storage, transmission, destruction, etc. is termed a data reuse (Custers & U Vrabec, 2016). The path from data to value is a sequence of value-adding processes that sum enables the final intent of their user (Taylor, 1982). The steps involved in data use are represented in the data lifecycle model as looping back since data used are not spent and could be reused if needed (Murdick & Munson, 1986).

The value of data comes from their use, and using data requires a purpose. Hence, the complete value of data can only be expressed through sharing them, extending their use to other purposes (Bambauer, 2012). The paradigm of big data is a prominent example of the benefits of the integration of multiple data sources into novel uses and value-creation (Kitchin, 2014). Many other descriptions of value creation from reusing shared data are described in the literature (Gelhaar & Otto, 2020). Generalization of data use motivates the development of data exchange ecosystems (Oliveira & Lóscio, 2018). They mediate the interactions between data providers and users through



the services (Hunke et al., 2020). This comes back to a distributed data lifecycle model, involving separate entities' contributions and their respective rights and responsibilities.

Risks and limitations to data sharing for reuse

The acceptability of a data transaction depends on its potential for negative outcomes (Gelhaar & Otto, 2020; Nwatchock A Koul & Morin, 2016). Participants' perceptions of fairness, governance, sovereignty, security, and privacy are among the principal obstacles to the adoption of data sharing (Driessen et al., 2022). These qualities relate to weaker control over the data supply and data use, resp. resulting from distributed data and processes (Gelhaar & Otto, 2020; Niemi, 2013). Participating in data exchanges means overcoming cultural, administrative, and economic barriers as well as complex legal and risk-related issues (Barry & Bannister, 2014). Participants have to rely on collaboration and trust to share data (De Prieëlle et al., 2020; Van Den Broek & Van Veenstra, 2015). Data users depend on data's fitness-for-use, relating to properties evolved along all processes leading to their current state (Carlson & Anderson, 2007; Wang & Strong, 1996). Data providers and users might have different knowledge about data quality, and its potential uses and value (Newlands et al., 2019). Providers' control over their data is also impacted by the number of participants and intermediaries (Al-Ruithe et al., 2019). Sharing data can lead to a broad range of impacts (Christin, 2020), and shared data can be used for potentially damaging purposes (van Zoonen, 2016) Moreover, data providers risk further unsanctioned reuse and diffusion of their data (Zuiderwijk & Janssen, 2015). Data misuse characterizes any use of data based on processes or purposes that are inappropriate within a system and the set of rules enforced (Zuiderwijk & Janssen, 2015), notwithstanding the nature and impact of their consequences. Rights, and thus liabilities, represent a subject of increasing complexity with the consideration of multiple stakeholders' respective economic, legal, and moral rights (Carlson & Anderson, 2007; Martin, 2013). Assessing whether sharing or using data is legitimate is not trivial, with complex data life cycles and evolving capabilities – especially regarding countering security- and privacy-preserving measures (Custers & Vrabec, 2016; Maniam & Singh, 2020). However, respect of rights and interests is a condition fundamental to broader data collaborations and forms the basis for acceptable data sharing and use systems.

Data governance

Data governance represents the exercise of authority and control over the management of data (Abraham et al., 2019), and specifically describes decision-making leading to rules and processes supporting access, quality, protection, and traceability of data and that of their use (Niemi, 2013). The governance of data sharing, then, is the set of strategies supporting the governance of data, their brokering, quality assessment, and transformation, and transaction enforcement (Driessen et al., 2022; OECD, 2019).

Governance of data sharing implicates fairness, which is defined by a set of mechanisms supporting collaboration and trust (De Prieëlle et al., 2020) and links to the establishment of an environment enabling mutual benefits from the integration of resources (Van Den Broek & Van Veenstra, 2015). Fairness involves ethics, showing the importance of value systems on whether



some data reuse is acceptable or not (Spiekermann, 2017). Other criteria include data sovereignty, the complete control over data including e.g., the physical location of systems processing them. Finally, participants need to trust that, beyond any technical implementation, data exchange will enforce these principles during and after the exchange.

Systems for Governed Data Sharing

Different approaches try to maintain trust between participants in data exchange, and potentially extend it to external parties. We describe here some practices and implementations forming a landscape of data exchange governance.

Governance models

The literature describes different governance models for data sharing and re-use, ranging from centralization to decentralization (Abbas, 2021; Driessen et al., 2022; Koutroumpis et al., 2020; Oliveira & Lóscio, 2018; Susha et al., 2017; Susha & Gil-Garcia, 2019; van de Ven et al., 2021). Data markets describe platforms that facilitate data exchange between parties by providing infrastructure and services (OECD, 2019), often deriving profit from their activities (Koutroumpis et al., 2020). They can provide services including data curation, integration, discovery, and matchmaking (van de Ven et al., 2021), mediate interactions with external providers, and implement measures to support different data governance strategies (Driessen et al., 2022). Centralized models describe systems with participants interacting with a single entity, whether it is an intermediary facilitating the exchange or representing the single data provider, resp. data user, of the ecosystem (Koutroumpis et al., 2020). Centralized systems provide strong control and security to the entity managing them, and proportionally limit the ability of other participants to exert governance. Decentralized systems build on technologies, protocols, and formats that programmatically support data reuse to set their operation. Decentralized exchanges offer increased flexibility and scalability, but do not prescribe adaptability. The lack of data governance and responsibility frameworks spanning across initiatives is an important challenge to the adoption (Susha et al., 2017).

Properties and services for distributed governance

Adoption of data sharing ecosystems requires preserving participants interests, but also their trust. Trust is essential to interactions between entities relying on control over assets and their use. Control implies setting and enforcing conditions for access and use. Access and use control can depend on access to the protected information (Vimercati et al., 2020), but limiting reuse on processing and purpose characteristics enables usage-specific sharing (Kaaniche et al., 2020). Traceability provides an important source of trust through the capacity to verify asset states. It can allow providers to enforce control, and users to verify fitness-for-use (Zhang et al., 2019). Provenance also enables stakeholders to evaluate both the acceptability of reuse and the validity of results. Interoperability requires adopting technical criteria for the data exchange (Janssen et al., 2014). They show the importance of data quality representation and metadata requirements for evaluating data before acquisition, extending to an assertion of data provenance



(Shankaranarayanan & Wang, 2007), or through integration of heterogeneous sources (Carlo et al., 2011). These dimensions are increasingly researched (Mons et al., 2017), and applied in public and research sectors (Murray-Rust, 2008). Identity frameworks, common data exchange models, and semantic descriptions support interoperability, trust, and data reuse quality. Distributed ledger technologies introduce properties suitable for distributing governance, enabling automating rule resolution for discovery and control (Rouhani, 2021). They also facilitate transparent interaction and distributed consensus (Kalbantner et al., 2021). The issue of control during data processing is answered by developments in computing, whether distributed at the source (Agahari et al., 2022) or in encrypted data (Naehrig et al., 2011). Preserving governance rights is central to data reuse. Current approaches propose limited systems that lack the adaptability needed for interoperation with existing systems. This necessitates reflecting on existing data-sharing systems, and their fit with current and future needs. In the following section, we describe our proposition for the data-sharing system model.

Model for Interoperable Data Exchange

Existing data exchanges demonstrate how different architectures and technologies can support systems answering select data-sharing use cases. We follow the assumption that entities owning data without the support of e.g., data subjects will face increasing risks. This may lead to a separation between data ownership and data uses (Franklin et al., 2005), and support a wider data sharing (Graef & Prüfer, 2021). Hence, providing systems preserving data sovereignty while allowing use is of great interest to both research and society. Our research hypothesis posits that an information system model for data sharing and use, ensuring appropriate transparency, trustworthiness, and accountability through distributed governance, would facilitate these developments. The conception of a generic model, based on a transaction validation service, can help to define additional essential properties to realize governance distribution and limit risks both from misuse and compliance – for different application domains. It can also demonstrate the potential for interoperability, which would allow different implementations to coexist and interface and maybe resolve the current fragmentation of platforms (Abbas, 2021). Moreover, it might facilitate the adaptation to evolving data-sharing regimes, whether from tightened regulations or to answer specific emergent situations, without compromising the interests of participants. Finally, such a system could provide methods for the traceability and accountability of data lifecycle records. This might support efforts toward ensuring automated processes' outputs when no central entity has complete control over data, processes, and underlying systems. Based on these assumptions, we consider it appropriate to work on addressing the conceptual and technical challenges raised by this research by proposing an approach toward the design of a technical framework. To achieve these objectives, this research will follow the design science methodology (Hevner & Chatterjee, 2010) and target the definition of a framework. It could be, then, instantiated into a data exchange prototype. Doing so, we hope to show how built-in distribution of governance can not only support trust and transparency in their environment but also form emerging capabilities.



Concept and Principles

Supporting fairness and trust in data sharing for reuse has different implications depending on the characteristics of data, processing, and purpose involved, but also on the participants and conditions for exchange. We use the principles and models described before, as well as other research items (Abbas, 2021; Driessen et al., 2022; OECD, 2019; van de Ven et al., 2021), to ground our requirements. This model should help to define additional properties essential to realize the distribution of governance and to limit misuse and compliance risks for specific domains. It should also demonstrate the potential for interoperability, which would allow different implementations to coexist and interface and maybe resolve the current fragmentation of platforms (Abbas, 2021). Moreover, it should facilitate the adaptation to evolving regulations and situations, without compromising the interests of participants. Finally, the model should provide for traceability and accountability of data lifecycle records, as potentially needed for ensuring explainability of automated processing outputs when no single entity has full control over both data, process, and the underlying system. Participation depends on the system ensuring participants' control over their assets, their access, and their use by others, hence the importance of *sovereignty*. To support it, we posit that allowing participants to define, implement, and enforce security measures to protect their assets before, throughout, and potentially after the exchange enables trusted operation. It should enforce compliance with legal frameworks and agreements between parties. For the system to be a practical answer to users' needs, we consider system *usability* and *adaptability* – of system, asset governance rules, and mechanisms to specific needs, its interoperability with existing systems, and its composability, considering scaling its complexity to answer operational needs. As a further objective, we aim to support the *economical use of data*, in that fairness requires limitation of processing to only what is needed for serving objectives aligned with stakeholders' legitimate interests. Similarly, we propose to allow for governance scalability and distribution, e.g., the implementation of open or private platforms of different degrees of centralization.

Design Proposition

We propose, building on existing approaches (Abbas, 2021; Nwatchock A Koul, 2019), a model for data exchange enabling distributed governance of its operation. The model described allows data exchange participants to declare rules for acceptable transactions, and validation of transactions against the resulting policies. Policies can be generic or specify a set of transactions, and result from agreement between data providers, data users, and any other entity holding rights over any other involved. This design does not limit the landscape of requirements, nor prescribe a negotiation protocol, as to not limit generalizability. We propose an architecture based on a core system and a modular set of services, allowing for system adaptation and interoperability. The system core manages the validation of transactions against policies, thus ensuring fairness and trust. It can alone manage simple, pre-arranged agreements. For more complex exchanges, it can follow data processes involving external services that match policy and transaction requirements. This allows systems to cover complex, specific, internal and external, security and operational needs. Examples of functionalities include data discovery, identification, data indexing and



catalog, but also interfaces with other data exchanges. The core and trusted external services compose an extended system that can transparently support various transactions. This provides for Below, we show describe the base components of the model, a set of minimal interaction between them, and potential implementations to fulfil the role of existing and still inexistant systems. Below, a block diagram of its instantiation (See **Error! Reference source not found.**).



Figure 1. System model

The system core and select services form an extended system that can serve as a generic autonomous decentralized data marketplace, enabling transactions between data providers and users on preset conditions. Its main components are described below (See Error! Not a valid bookmark self-reference.).

Role	Description			
System core	This element provides the essential services enabling trusted and fair transactions.			
	Its processes enforce the set of principles negotiated by participants prior to the			
	exchange.			
Provider/User	Entities able to share or to use some data, resp. Providers and users can be data			
	subjects, owner, or any entity that has the technical capacity to provide and use data			
	assets. Both may also provide services.			
Third party	Entities controlling services providing supplementary ecosystem functions. Any			
providers	entity can provide services if those, and their use, respect the policy.			



Ext. rightsholders Entities holding some rights over the system, its components, operation, or participants, without direct control over them.

The sequence of steps to instantiate the model into a system able to validate data processes is as follows: (i) an initial number of participants negotiate and sign a set of policies matching their requirements; (ii) the system core receives data and service descriptions from potential providers and indexes the ones that can enforce parts of the policies; (iii) the set of acceptable services extends the system core, and allows entities to conduct data transactions respecting the policies initially negotiate; (iv) any entity can propose a transaction, which is validated against applicable policies; (v) the transaction – if valid – is executed by the sequence prescribed by its instructions and the policy. The particular sequence of operations achieving data use depends on the sets of policies, their implementation, and on the process and purpose of said use. Policies can describe any set of rules, on any parameter of the transaction, participants, and their environment.

Discussion

The proposed model can adapt to various systems, including literature-described exchanges. It does not prescribe specific policy or transaction validation methods to support any sharing scheme. Identical policies can be instantiated into different systems and service sets, but any system can operate with all others. The model enables the definition and enforcement of policies based on propriety-entity criteria. The parameters are not constrained, but the interpretable syntax is required for automation and composable policies would benefit general use. The system can help participants negotiate a policy and validate transactions against it. Simple cases may have trivial negotiation and validation, while others might become difficult to represent. Some policies may require access to inaccessible or untrusted data, necessitating reliance on a trusted third party for validation, and adding content to syntax constraints. The question of whether policies and transactions should be publicly readable is not easily answerable. Transparency can support data and service provisioning, allowing anyone to verify matches and ensure fairness, but can bring security risks and other negative consequences to participants.

Conclusion

Efficient, fair, and trusted data sharing benefits data providers, users, and other stakeholders beyond them. Data exchanges facilitate these exchanges, limiting risks to enable their generalization beyond specific contexts. Various models exist, using different governance instruments. Tailored to participants, data, processes, and transactions, and technologies, these systems are often not generalizable nor interoperable. Our research has for objective to define a flexible and interoperable model for data-sharing, providing the fairness and trustworthiness required in cross-sector data collaboration. The model proposed can serve as a foundation for fair, accountable, and trusted transactions. Current technologies answer the requirements for building systems following this framework. Future steps include the work on an extensible description scheme covering entities, services, policies, transactions, and assets, and the design of policy and validation engines.



References

Abbas, A. (2021). Designing data governance mechanisms for data marketplace meta-platforms.

- Abraham, R., Schneider, J., & vom Brocke, J. (2019). Data governance: A conceptual framework, structured review, and research agenda. *International Journal of Information Management*, 49, 424–438.
- Agahari, W., Ofe, H., & de Reuver, M. (2022). It is not (only) about privacy: How multi-party computation redefines control, trust, and risk in data sharing. *Electronic Markets*, *32*(3), 1577–1602.
- Al-Ruithe, M., Benkhelifa, E., & Hameed, K. (2019). A systematic literature review of data governance and cloud data governance. *Personal and Ubiquitous Computing*, 23(5), 839–859.
- Bambauer, J. R. (2012). Tragedy of the data commons. *Harvard Journal of Law and Technology*, 25(1), 67.
- Barry, E., & Bannister, F. (2014). Barriers to open data release: A view from the top. *Information Polity*, *19*(1/2), 129–152.
- Carlo, B., Daniele, B., Federico, C., & Simone, G. (2011). A data quality methodology for heterogeneous data. *International Journal of Database Management Systems*, 3(1), 60–79.
- Carlson, S., & Anderson, B. (2007). What are data? The many kinds of data and their implications for data re-use. *Journal of Computer-Mediated Communication*, 12(2), 635–651.
- Christin, A. (2020). What data can do: a typology of mechanisms. *International Journal of Communication*, 14, 20.
- Custers, B., & U Vrabec, H. (2016). Big data and data reuse: A taxonomy of data reuse for balancing big data benefits and personal data protection. *International Data Privacy Law*, 6(1), 4–15.
- De Prieëlle, F., De Reuver, M., & Rezaei, J. (2020). The role of ecosystem data governance in adoption of data platforms by internet-of-things data providers: Case of Dutch horticulture industry. *IEEE Transactions on Engineering Management*, 1–11.
- Driessen, S. W., Monsieur, G., & Van den Heuvel, W.-J. (2022). Data market design: A systematic literature review. *IEEE Access*, *10*, 33123–33153.
- Franklin, M., Halevy, A., & Maier, D. (2005). From databases to dataspaces: A new abstraction for information management. *ACM SIGMOD Record*, *34*(4), 27–33.



- Gelhaar, J., & Otto, B. (2020, June 22). Challenges in the emergence of data ecosystems. *Proceedings of the PACIS 2020 Conference*. https://aisel.aisnet.org/pacis2020/175
- Graef, I., & Prüfer, J. (2021). Governance of data sharing: A law & economics proposal. *Research Policy*, *50*(9), 104330.
- Hevner, A., & Chatterjee, S. (2010). Design research in information systems.
- Hunke, F., Seebacher, S., Schüritz, R., & Satzger, G. (2020). Pathways from data to value: identifying strategic archetypes of analytics-based services. In WI2020 Zentrale Tracks (pp. 1035–1050). GITO Verlag. https://library.gito.de/2021/07/13/wi2020-zentrale-tracks-74/
- Janssen, M., Estevez, E., & Janowski, T. (2014). Interoperability in big, open, and linked dataorganizational maturity, capabilities, and data portfolios. *Computer*, 47(10), 44–49.
- Kaaniche, N., Laurent, M., & Belguith, S. (2020). Privacy enhancing technologies for solving the privacy-personalization paradox: Taxonomy and survey. *Journal of Network and Computer Applications*, 171, 102807.
- Kalbantner, J., Markantonakis, K., Hurley-Smith, D., Shepherd, C., & Semal, B. (2021). A DLTbased Smart Contract Architecture for Atomic and Scalable Trading (arXiv:2105.02937). arXiv.
- Kitchin, R. (2014). *The data revolution: Big data, open data, data infrastructures & their consequences.* SAGE Publications.
- Koutroumpis, P., Leiponen, A., & Thomas, L. D. W. (2020). Markets for data. *Industrial and Corporate Change*, 29(3), 645–660.
- Maniam, J. N., & Singh, D. (2020). Towards data privacy and security framework in big data governance. *International Journal of Software Engineering and Computer Systems*, 6(1), Article 1.
- Martin, S. (2013). Risk analysis to overcome barriers to open data. *Electronic Journal of E-Government*, 11(2), pp348-359-pp348-359.
- Mons, B., Neylon, C., Velterop, J., Dumontier, M., da Silva Santos, L. O. B., & Wilkinson, M. D. (2017). Cloudy, increasingly FAIR; revisiting the FAIR Data guiding principles for the European Open Science Cloud. *Information Services & Use*, 37(1), 49–56.
- Murdick, R. G., & Munson, J. C. (1986). *MIS, concepts and design*. Prentice-Hall. http://archive.org/details/misconceptsdesig00murd
- Murray-Rust, P. (2008). Open data in science. Nature Proceedings, 1-1.
- Naehrig, M., Lauter, K., & Vaikuntanathan, V. (2011). Can homomorphic encryption be practical? Proceedings of the 3rd ACM Workshop on Cloud Computing Security Workshop, 113–124.



- Newlands, G., Lutz, C., & Fieseler, C. (2019). Trading on the unknown: Scenarios for the future value of data. *The Law & Ethics of Human Rights*, *13*(1), 97–114.
- Niemi, E. (2013). Designing a data governance framework. *Proceedings of the 36th ISR Seminar Scandinavia*. Information Systems Research Seminar in Scandinavia. https://research.aalto.fi/en/publications/designing-a-data-governance-framework
- Nwatchock A Koul, A. S. (2019). A framework for fair and responsible data market ecosystems [PhD thesis, Université de Genève]. https://archive-ouverte.unige.ch/unige:121388
- Nwatchock A Koul, A. S., & Morin, J.-H. (2016). Towards a taxonomy of data and guiding principles for data markets. *Proceedings of the 11th Pre-ICIS Workshop on Information Security and Priv.*
- OECD. (2019). Enhancing access to and sharing of data: Reconciling risks and benefits for data re-use across societies. Organisation for Economic Co-operation and Development.
- Oliveira, M. I. S., & Lóscio, B. F. (2018). What is a data ecosystem? [1-9].
- Regulation on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (Data Protection Directive), no. 2016/679, *The European Parliament and Council of the European Union (2016)*.
- Rizk, A., Bergvall-Kåreborn, B., & Elragal, A. (2018). Towards a taxonomy of data-driven digital services. *Proceedings of the 51th Hawaii International Conference on System Sciences*. http://hdl.handle.net/10125/50022
- Rouhani, S. (2021). Data trust framework using blockchain and smart contracts [Thesis, University of Saskatchewan]. https://harvest.usask.ca/handle/10388/13419
- Shankaranarayanan, G., & Wang, R. Y. (2007). IPMAP: Current State and Perspectives. 18.
- Spiekermann, S. (2017). It's all about design: An ethical analysis of personal data markets. In D. J. B. Svantesson & D. Kloza (Eds.), *Trans-Atlantic Data Privacy Relations as a Challenge* for Democracy (Vol. 4, pp. 391–404). Intersentia.
- Susha, I., & Gil-Garcia, J. R. (2019, January 8). A collaborative governance approach to partnerships addressing public problems with private data.
- Susha, I., Janssen, M., & Verhulst, S. (2017). Data collaboratives as "bazaars"?: A review of coordination problems and mechanisms to match demand for data with supply. *Transforming Government: People, Process and Policy*, 11(1), 157–172.
- Taylor, R. S. (1982). Value-added processes in the information life cycle. *Journal of the American Society for Information Science*, *33*(5), 341–346.



- van de Ven, M., Abbas, A. E., Kwee, Z., & De Reuver, M. (2021). Creating a taxonomy of business models for data marketplaces. *Proceedings of the 34th Bled Conference Proceedings*, 309–321.
- Van Den Broek, T., & Van Veenstra, A. F. (2015). Modes of governance in inter-organizational data collaborations. *ECIS 2015 Completed Research Papers*, 0–12.
- van Zoonen, L. (2016). Privacy concerns in smart cities. *Government Information Quarterly*, 33(3), 472–480.
- Vimercati, S., Foresti, S., Livraga, G., & Samarati, P. (2020). Toward owners' control in digital data markets. *IEEE Systems Journal*, *PP*, 1–8.
- Wang, R. Y., & Strong, D. M. (1996). Beyond accuracy: What data quality means to data consumers. *Journal of Management Information Systems*, 12(4), 5–33.
- Zhang, R., Indulska, M., & Sadiq, S. (2019). Discovering data quality problems. *Business & Information Systems Engineering*, 61(5), 575–593.
- Zuiderwijk, A., & Janssen, M. (2015). Towards decision support for disclosing data: Closed or open data? *Information Polity*, 20(2/3), 103–117. CrossRef.

Author Biography

Emmanuel Kellner, M.Sc. is a doctoral student in Information Systems in the Institute of Information Service Science at the University of Geneva.



Internet of things and smart technologies in oral health: A systematic mapping study

[Research-in-Progress]

Susana J. Calderon, Illinois State University, USA, <u>sjcalde@ilstu.edu</u>Stephen Mujeye, Illinois State University, USA, <u>smujey1@ilstu.edu</u>

Abstract

The Internet of Things (IoT) has been around for many years, and specific fields utilizing the benefit of connectivity, networking, and processing information from devices are well documented. Over the years, the IoT and the integration in oral health made through combining the Internet of Things (IoT) with smart technologies such as mobile phones and electronic medical records have been on the rise. There are different uses of IoT in dentistry and the benefits of applications of big data for interventional studies in oral health. Using IoT requires an understanding of acceptability and responsibility for preserving privacy for the user and the collected data, as the integration of IoT in health presents some challenges with privacy and security. There are advantages and challenges to integrating the Internet of Things (IoT) with smart technology in oral health requiring interdisciplinary collaboration to maximize benefits and minimize vulnerabilities. In this work-in-progress study, we seek to outline the trends and challenges in research and literature pertaining to IoT devices and smart technologies in oral health. The systematic mapping methodology is proposed to identify and analyze the trends and challenges in the research literature about IoT devices and smart technologies in oral health. The paper ends with a discussion and conclusion.

Keywords: Internet of Things (IoT), Internet of Dental Things, Oral health, wearable healthcare devices, smart health systems, Internet of medical things, security.

Introduction

The term Internet of Things (IoT) is used to describe a paradigm in which technology objects are combined with identifying, sensing, networking, and processing features that give them the capability to communicate with each other and other devices over the Internet (Whitmore et al., 2015). The convergence of the Internet and Sensor Networks offers new possibilities, allowing machine-to-machine communication using the Internet. On the other hand, the International Telecommunication Union defined IoT as "a global infrastructure for the Information Society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies" (Wright, 2015, para. 3). Researchers pointed out prominent areas of IoT application as smart industry (intelligent production systems), smart home or building area (intelligent thermostats), smart energy (smart



electricity), smart transport (vehicle fleet tracking), and smart health (chronic disease management) (Wortmann & Flüchter, 2015). IoT technologies have been applied in virtually all areas.

IoT devices are incorporated into healthcare as embedded or wearable sensors on the human body and are used to collect physiological information, including temperature, blood pressure, and electrocardiograph readings (Pradhan et al., 2021). IoT continues to be used in healthcare to transmit data from the patient to the healthcare provider. Andion et al. (2018) pointed out that installing low-cost sensors in patient homes to collect behaviors and patterns of the patient is another use of IoT. The information collected can be analyzed to detect any anomalies, thereby improving a patient's health. Table 1 shows some of the ways that IoT devices can be used in healthcare.

Device	Purpose
Wearable biosensors	Used to monitor vital signs including temperature, heart rate, breathing rate
Smart thermometers	Used to track and monitor body temperature
Connected inhalers	Used to track respiratory conditions like asthma and chronic obstructive pulmonary disease
Smart watch monitoring	Used to monitor and measure blood oxygen
Smart glucose monitors	Used to monitor patient blood sugar levels
Automated insulin delivery (AID) systems	Used to deliver continuous supply of insulin into the patient

Table 1. Uses of IoT Devices in Healthcare

While the benefits of IoT devices and other smart technologies are clear, they also provide some challenges. The challenges include the fact that IoT devices collect and track personal data which presents some privacy challenges (Bhadauria & Chennamaneni, 2022). Consequently, the exchanging of data between IoT devices and other cloud-based applications increases the attack surface thereby putting all connected people and devices at risk of cybersecurity attacks.

Theoretical Background

Pradhan et al. (2021) pointed out that IoT refers to a network of physical objects incorporating sensors, software, and other technologies that connect and exchange data with other devices over the Internet. In healthcare, IoT devices in the form of wearable devices with sensors have been used in many situations including the diagnosis of COVID-19 (Al Bassam et al., 2021). Ghubaish et al. (2021) mentioned that their section of IoT referred to as Internet-of-Medical Things (IoMT) which, allows medical health professionals to monitor patients with chronic diseases. Specifically,



IoT devices were used to measure patient vital signs and notify medical authorities when quarantined patients violated quarantine restrictions. Qureshi and Krishnan (2018) mentioned that wearable body sensors provide a solution for remotely monitoring healthcare. Healthcare professionals such as doctors can continuously receive crucial patient information, assisting patients sooner rather than later. Kang and Hwang (2022) submitted that the healthcare and medical industry are being changed by adopting IoT devices in healthcare operations. IoT devices are used in the measurement of patient kinetic data, such as calorie consumption and the number of steps taken. IoT devices, also called smart health systems, can be used to monitor physiological body aspects such as skin and motion to detect early signs of health problems (Pilavaki, et al., 2016). Furthermore, oral health is an integral part of overall health. There is an effort to increase awareness and prevention of oral health diseases associated with systematic chronic conditions. Children and adolescents are at high risk for dental caries and poor oral hygiene due to multifactorial lack of access, lack of good oral hygiene practice, increased consumption of sugary drinks, and lack of healthy nutrition. In addition to practicing poor oral hygiene and consuming large quantities of sugary beverages, adolescents often spend hours on their cellphones, as many as eight hours daily (Fobian et al., 2016). The "iGeneration" spends hours with individualized technology. Therefore, large amounts of data are collected from these devices ("big data") and in the iCloud for storage. Here is the opportunity to use technology sensitively to capture behavioral data and use it to improve oral health outcomes.

However, the field of dental IoT technologies needs to advance further to catch up with other fields using IoT, but some limitations in software performance and synchronization with dental equipment prevent flawless incorporation of the technology. Some proponents suggest that the solution is more complex for integration into the dentistry (Stohler, 2021). The benefits of using the interface during COVID-19 allowed timely connections between patients and dentistry providers. For those patients dealing with chronic illness and periodontal disease, integration of the interface will work nicely to support these patients and monitor the progression of other systematic diseases. This presents an opportunity to review the training and education of dental health care providers and incorporate aspects of cross-training with interface applications and reasoning in prevention.

Moreover, incorporating technology and IoT into the academic field of dentistry can improve educational activities. For example, using IoT in simulation settings to teach dental radiology safe practices eliminates radiation exposure and provides a means to submit data to a telecommunication network to store for the use of students as they determine and diagnose dental disease (Kim et al., 2019). Another innovative use of IoT to assist dental students in learning dental microbiology is to connect them with laboratory games that integrate bio-bacteria (Kim & Poslad, 2019). Innovative ways to incorporate IoT in dentistry with future of dentistry providers. These are only two examples of innovative ways to incorporate IoT in dentistry education and provide future dentistry providers with the skills they will need to thrive in our remote hybrid world.





Figure 1. Patient sending dental data to provider

Over the years, different industries have used IoT devices and it is predicted that the worldwide use of IoT devices will triple by 2020 (IoT Connected Devices Worldwide 2019-2030, n.d.). Figure 2 shows the number of IoT connected devices over the years. Moreover, the growth of these devices is linked to the worldwide Internet, and smartphone using social media platforms such as Facebook and Instagram have been known to link to these devices. Advances in cloud-based technology and the Internet of Dental Things (IoDT) have resulted in the integration of IoDT devices (such as smartphones and tablets) with oral health monitoring; data collection is recommended. With this integration comes the means to collect data that can be used to facilitate the prediction of risk for dental caries and periodontal diseases. The use of this innovative technological approach is encouraged as it will facilitate the prediction of risk for dental caries and periodontal diseases. In addition, the efforts toward early detection in prevention related to oral health will bring a new perspective on how to approach these multifactorial problems (Salagare & Prasad, 2020). Moreover, the Internet of Dental Things (IoDT) integrating smart toothbrushes with a sensor to connect with the patients' cell phones, tablets, or personal computers offers a streaming approach to collect reliable data. The toothbrushing frequency and pressure applied are vital information for the user, which provides immediate feedback (Salagare & Prasad, 2020). All the devices connected suggest a valuable model for oral health in dentistry. The complete data is uploaded to the cloud-based server in which different devices can collect information, not only smart toothbrushes but also wearable sensors. It offers an excellent future for managing and monitoring dental and chronic diseases using the IoDT.





Figure 2: IoT Connected devices over the years

Digital devices (e.g., teledentistry, digital scanning, 3-D printing, and others) are -known and often used daily in dentistry on a global level (Salagare & Prasad, 2020). Furthermore, IoT devices are connected and controlled, from the sensor device to the server, collecting data sets from dentistry patients and contributing to a smart world encompassing many other healthcare fields (Ganesh & Sugumar, 2021). Researchers have found that there is a lack of major research in incorporating IoDT, even though it is poised to revolutionize the field of dentistry (Ganesh & Sugumar, 2021).

Researchers have been incorporating wearable devices (such as intraoral devices) and connecting them with IoDT (Ganesh & Sugumar, 2021). These wireless devices are getting smaller and more efficient, seamlessly incorporating dentistry medical records using cloud-based technology. However, there are challenges many healthcare systems and machines do not cross-talk with one another. Opportunities should continue to expand in the healthcare fields of dentistry, medicine, nursing, and others to speed connectivity with IoT systems and improve patient care. We need to continue emphasizing IoT improvement concerning data management and storage, user-friendly interface, systems' communication, security, energy efficiency, and data monitoring.

Privacy

While it is clear that big data benefits dental practice and research, challenges such as privacy, anonymity, security, and informed consent require solutions (Favaretto et al., 2020). Unauthorized entities can easily access sensitive patient information, leading to a breach in patient privacy and confidentiality. Security issues with IoT devices have been an issue over the years. During the early adoption of IoT, Kumar, Vealey, and Srivastava (2016) submitted that security and privacy were the main impediments to these devices' wide acceptance and adoption. Vishnu, Ramson, and Jegan (2020) concurred that security and privacy challenges and trends limit users' acceptance and usage of IoMT. Bhadauria and Chennamaneni (2022) pointed out that cyber-attacks on IoT devices significantly increased to 300% in 2019, with 2.9 billion events recorded during that year.



One possible solution to patient privacy and security is implementing a three-zone confidentiality model of networked and non-networked medical databases (Favaretto et al., 2020). The model includes different access and security levels based on the sensitivity of patient data being accessed.

Research Questions and Methodology

This study aims to outline the trends and challenges in research and literature pertaining to IoT devices and smart technologies in oral health. The systematic mapping methodology will be used to identify and analyze the trends and challenges in IoT devices and smart technologies in oral health. The systematic mapping study will be used because of its ability to provide an overview of a research area through classification and counting contributions as it relates to the classification categories (Petersen et al., 2015). Specifically, the systematic mapping study will address the research questions in Table 2.

RQ No.	Research Question	Motivation		
RQ1	What are the publication trends of IoT devices and smart technologies in oral health?	To identify and discover current trends of published articles on IoT devices and smart technologies in oral health.		
RQ2	What are the trends in literature and publication frequency of research in IoT devices and smart technologies in oral health?	To identify and discover publication frequency of published articles on IoT devices and smart technologies in oral health.		
RQ3	What impacts does IoT devices and smart technologies have had on oral health?	To identify challenges pointed out by researchers in published articles on IoT devices and smart technologies in oral health.		
RQ4	What challenges are faced in the implementation of IoT devices and smart technologies in oral health?	To identify challenges pointed out by researchers in published articles on IoT devices and smart technologies in oral health.		
RQ5	Who are the active researchers on the use of IoT devices and smart technologies in oral health?	To identify active researchers in published articles on IoT devices and smart technologies in oral health.		

|--|



The systematic mapping methodology will be used based on the method which was proposed by Petersen et al. (2008). The mapping process with all the phases we will carry out is listed in Figure 3. The phases consist of five steps and corresponding outcomes.



Figure 3. The Systematic Mapping Process

The first process of definition of research has been completed and the next process will be to conduct a search of all relevant articles. The following databases will be used to search published articles on IoT devices and smart technologies in oral health:

- Computers & Applied Sciences Complete
- IGI Global Ebooks Collection
- ACM Digital Library
- Science Direct

Table 4. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Articles that discuss trends and/or challenges of IoT and smart technologies in oral health	Articles that do not discuss trends and/or challenges of IoT and smart technologies in oral health
	Articles that are not in English
	Articles with the main output of a systematic literature review or mapping study
	Book chapters
	Articles not accessible in full text
	Duplicate studies



The keywords we will use for searching will be acquired from our background research, as listed in the theoretical framework section above. The search included the keyword "Internet of Things" and other related terms. The search string will contain key phrases IoT, the Internet of medical things, wearable healthcare devices, smart health systems, and the Internet of dental things. After searching and getting results of articles from the databases, the screening process will be conducted in order to remove duplicate articles. The screening will be performed using the inclusion and exclusion criteria in Table 4.

During the data extraction phase, relevant information from the articles will be used to address the research questions. The data extraction form for each selected article as shown in Table 5 will be used.

Data Item	Value	RQ
Title		
Authors		
Publication trend		RQ1
Publication frequency		RQ2
Impacts of IoT devices and smart technologies on oral health		RQ3
Challenges		RQ4
Active researchers		RQ5

Table 5. Data extraction form

The final step will be to present the results of the mapping study using frequency tables and other graphs. The y tables and graphs will help answer all the research questions and identify trends and challenges of IoT devices and smart technologies in oral health. To the best of our knowledge, this study will be the first to answer questions about IoT devices and smart technologies in oral health.

Discussion and Conclusion

Our study aims to outline the trends and challenges in research and literature pertaining to IoT devices and smart technologies in oral health. We seek to elucidate the current knowledge in relation to the Internet of Things in dentistry and the uses of smart technology for oral health. Big data presents opportunities in health care, including oral dentistry. Data analytics tools can be applied to provide solutions in oral dentistry. Data mining tools can also be used to analyze and evaluate collected data. The results have the potential to advance the dental profession. Using technology, devices, and the big data subsequently collected offers the opportunity to predict and



move us toward a world in which we could notify users not only about their risk for a disease but empower them to take action toward their health before it is too late. The increase in the number of IoT devices over the years and the data collected is well documented. People are now using more and more smart devices and mobile-based applications which connect to IoT devices. IoT devices can be used in dental care to learn more about brushing patterns and thereby provide some solutions. However, the use of IoT devices presents challenges in privacy and security. Proper mitigation measures can and must be put in place if the benefits of IoT devices are fully utilized.

The IoDT can assist with monitoring oral health diseases and outcomes, and with the implementation of different technologies and devices, it is possible to offer these services to patients and users. It is common for people to employ wearable devices to collect daily wellness information; many people, for example, use a Fitbit device or Apple watch to track health habits and information. Dentistry healthcare providers will see the benefits of using IoDT when researchers in the field collaborate with colleagues in other disciplines, such as IT, medicine, nursing, and psychology. Currently, groups advocating for the acceptance of IoT in dentistry are starting to understand how it works and how to implement it, as well as the need for professional development among dentistry providers and support staff in this area. The results of these efforts will benefit patients or users and improve the workflow of clinical practices. Patients crave current information on their health status. Moreover, the population's makeup is changing in age and values. The future of dentistry includes utilizing technologies such as the IoT and integrating smart technology; in collaboration with other disciplines, the global benefits of up-to-the-minute oral healthcare knowledge can be realized.

In conclusion, we recognize the challenges of implementing technologies like the Internet of Things and integrating smart technologies in oral health. The field of dentistry can significantly benefit from the use of IoT devices and the analysis of information available through big data. Measures must be put in place to address privacy and security challenges. This is a relatively new field in which the collaboration of interdisciplinary teams can advance a significant shift toward improving oral health, particularly among young people.

Acknowledgement

We thank the anonymous referees for their careful review and valuable suggestions.

References

Al Bassam, N., Hussain, S. A., Al Qaraghuli, A., Khan, J., Sumesh, E. P., & Lavanya, V. (2021). IoT based wearable device to monitor the signs of quarantined remote patients of COVID-19. *Informatics in Medicine Unlocked*, 24, 100588–100588. <u>https://doi.org/10.1016/j.imu.2021.100588</u>



- Bhadauria, & Chennamaneni, A. (2022). Do desire, anxiety and personal innovativeness impact the adoption of IoT devices? *Information and Computer Security*, *30*(5), 730–750. https://doi.org/10.1108/ICS-07-2021-0096
- Alauddin, M. S., Baharuddin, A. S., & Mohd Ghazali, M. I. (2021). The modern and digital transformation of oral health care: A mini review. *Healthcare*, 9(2), Article 2. <u>https://doi.org/10.3390/healthcare9020118</u>
- Andión, J., Navarro, J. M., López, G., Álvarez-Campana, M., & Dueñas, J. C. (2018). Smart behavioral analytics over a low-cost IoT wi-fi tracking real deployment. *Wireless Communications and Mobile Computing*, 2018, e3136471. https://doi.org/10.1155/2018/3136471
- Erbe, C., Klees, V., Ferrari-Peron, P., Ccahuana-Vasquez, R. A., Timm, H., Grender, J., Cunningham, P., Adam, R., Farrell, S., & Wehrbein, H. (2018). A comparative assessment of plaque removal and toothbrushing compliance between a manual and an interactive power toothbrush among adolescents: A single-center, single-blind randomized controlled trial. *BMC Oral Health*, 18(1), 130. <u>https://doi.org/10.1186/s12903-018-0588-1</u>
- Favaretto, M., Shaw, D., De Clercq, E., Joda, T., & Elger, B. S. (2020). Big data and digitalization in dentistry: A systematic review of the ethical issues. *International Journal* of Environmental Research and Public Health, 17(7), E2495. <u>https://doi.org/10.3390/ijerph17072495</u>
- Fobian, A. D., Avis, K., & Schwebel, D. C. (2016). The impact of media use on adolescent sleep efficiency. *Journal of Developmental and Behavioral Pediatrics: JDBP*, *37*(1), 9–14. https://doi.org/10.1097/DBP.0000000000239
- Ganesh, B., & Sugumar, K. (2021). Internet of Things—A novel innovation in dentistry. *Journal* of Advanced Oral Research, 12(1), 42–48. <u>https://doi.org/10.1177/2320206820980248</u>
- Ghubaish, A., Salman, T., Zolanvari, M., Unal, D., Al-Ali, A., & Jain, R. (2020). Recent advances in the internet-of-medical-things (IoMT) systems security. *IEEE Internet of Things Journal*, 8(11), 8707-8718. <u>http://doi.org/10.1109/JIOT.2020.3045653/</u>
- Hung, M., Park, J., Hon, E. S., Bounsanga, J., Moazzami, S., Ruiz-Negrón, B., & Wang, D. (2020). Artificial intelligence in dentistry: Harnessing big data to predict oral cancer survival. World Journal of Clinical Oncology, 11(11), 918–934. <u>https://doi.org/10.5306/wjco.v11.i11.918</u>
- IoT connected devices worldwide 2019-2030. (n.d.). Statista. https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/
- Kang, & Hwang, Y. C. (2022). Exploring the factors affecting the continued usage intention of IoT-based healthcare wearable devices using the TAM model. *Sustainability (Basel, Switzerland)*, 14(19), 12492–. <u>https://doi.org/10.3390/su141912492</u>



- Kumar, Vealey, T., & Srivastava, H. (2016). Security in Internet of Things: Challenges, solutions and future directions. *Proceedings of the 49th Hawaii International Conference on System Sciences (HICSS)*, 5772–5781. <u>https://doi.org/10.1109/HICSS.2016.714</u>
- Kim, R., & Poslad, S. (2019). The thing with e.coli: Highlighting opportunities and challenges of integrating bacteria in IoT and HCI (arXiv:1910.01974). arXiv. <u>https://doi.org/10.48550/arXiv.1910.01974</u>
- Kim, S.-J., Min, J.-H., & Kim, H.-N. (2019). The development of an IoT-based educational simulator for dental radiography. *IEEE Access*, 7, 12476–12483. <u>https://doi.org/10.1109/ACCESS.2019.2891569</u>
- Petersen, K., Feldt, R., Mujtaba, S., & Mattsson, M. (2008, June). Systematic mapping studies in software engineering. *Proceedings of the 12th International Conference on Evaluation and Assessment in Software Engineering (EASE) 12* (pp. 1-10).
- Petersen, Vakkalanka, S., & Kuzniarz, L. (2015). Guidelines for conducting systematic mapping studies in software engineering: An update. *Information and Software Technology*, 64, 1– 18. <u>https://doi.org/10.1016/j.infsof.2015.03.007</u>
- Pilavaki, Parolo, C., McKendry, R., & Demosthenous, A. (2016). Wireless paper-based biosensor reader for the detection of infectious diseases at the point of care. *IEEE* SENSORS, 1–3. <u>https://doi.org/10.1109/ICSENS.2016.7808907</u>
- Pradhan, B., Bhattacharyya, S., & Pal, K. (2021). IoT-based applications in healthcare devices. *Journal of Healthcare Engineering*, 2021, 6632599.
- Qureshi, & Krishnan, S. (2018). Wearable hardware design for the Internet of Medical Things (IoMT). *Sensors (Basel, Switzerland), 18*(11), 3812–. <u>https://doi.org/10.3390/s18113812</u>
- Salagare, S., & Prasad, R. (2020). An overview of Internet of Dental Things: New frontier in advanced dentistry. Wireless Personal Communications, 110(3), 1345–1371. <u>https://doi.org/10.1007/s11277-019-06790-4</u>
- Sisinni, Saifullah, A., Han, S., Jennehag, U., & Gidlund, M. (2018). Industrial Internet of Things: Challenges, opportunities, and directions. *IEEE Transactions on Industrial Informatics*, 14(11), 4724–4734. <u>https://doi.org/10.1109/TII.2018.2852491</u>
- Stohler, C. (2021). INVITED COMMENTARY: Lessons learned: Lots of Internet of Things do not make a 21st century health system. But what does? *The International Journal of Prosthodontics*, 34(3), 286–289. <u>https://doi.org/10.11607/ijp.2021.3.ic</u>
- Underwood, B., Birdsall, J., & Kay, E. (2015). The use of a mobile app to motivate evidencebased oral hygiene behaviour. *British Dental Journal*, *219*(4), E2. <u>https://doi.org/10.1038/sj.bdj.2015.660</u>



- Vishnu, Ramson, S. R. J., & Jegan, R. (2020). Internet of Medical Things (IoMT) An overview. *Proceedings of the 5th International Conference on Devices, Circuits and Systems (ICDCS)*, 101–104. https://doi.org/10.1109/ICDCS48716.2020.243558
- Whitmore, A., Agarwal, A., & Da Xu, L. (2015). The Internet of Things—A survey of topics and trends. *Information Systems Frontiers*, 17(2), 261–274. <u>https://doi.org/10.1007/s10796-014-9489-2</u>
- Wortmann, F., & Flüchter, K. (2015). Internet of things. *Business & Information Systems* Engineering, 57(3), 221–224. <u>https://doi.org/10.1007/s12599-015-0383-3</u>
- Wright, E. S. (2015). DECIPHER: Harnessing local sequence context to improve protein multiple sequence alignment. *BMC Bioinformatics*, 16, 322. <u>https://doi.org/10.1186/s12859-015-0749-z</u>



A gap analysis of knowledge management performance using a State Enterprise Assessment Model (SE-AM): A case study of a Thai airport operator

[Complete Research]

Kom Campiranon, Thammasat University, Thailand, kom@citu.tu.ac.th

Abstract

This paper has examined the knowledge management performance of a Thai airport operator under State Enterprise Assessment Model (SE-AM) guidelines. By utilizing a qualitative research approach, data were collected from employees involved in the SE-AM process through in-depth interviews regarding their expectations of SE-AM performance in 2026, when compared with actual performance in 2021. The results show that the largest gaps were in the following SE-AM criteria: "Leading the organization" (1.50 gap score), "KM outcome" (1.10 gap score), "Planning and support resources" and "KM process" (0.80 gap score). To fill such gaps, this paper has revealed a wide array of managerial implications which were highlighted by the respondents, from leadership-driven strategies and process-driven strategies to a proven result of key performance with KM implemented as part of the process.

Keywords: Airport operator, gap analysis, state enterprise, assessment model.

Introduction

State enterprises, which are government-owned business enterprises, play a key role in national development in the provision of critical infrastructure, such as energy, water supply, transportation, communication, and telecommunications. They also play important roles in agriculture and industry. These state enterprises are considered key governmental instruments for national development (Rodmorn et al., 2019). State enterprises play an important role in Thailand's economy (Nitikasetsoontorn, 2019), and every state enterprise strives to perform well in the annual performance evaluation conducted by Thailand's State Enterprise Policy Office (SEPO), which is based on operational excellence criteria. By applying the frameworks and criteria of the Malcolm Baldrige National Quality Award (MBNQA) and the Thailand Quality Award (TQA), SEPO established the State Enterprise Performance Appraisal (SEPA) framework (Wipulanusat et al., 2016).

The SEPA framework comprises seven criteria, which reflect the operations and results achieved by state enterprises, including organizational leadership (criterion 1), strategic planning (criterion 2), customer and market focus (criterion 3), knowledge management or KM (criterion 4), personnel focus (criterion 5), process management (criterion 6) and results (criterion 7) (State



Enterprise Policy Office, 2023a). Whilst SEPA is widely accepted as an integrated framework for organizational development (Wipulanusat et al., 2016), the State Enterprise Policy Office (2023b) integrated both of its major assessment models, including SEPA and the organization management system, into the State Enterprise Assessment Model (SE-AM) in 2018. The criteria of the SE-AM framework will be discussed in the next section.

The State Enterprise Assessment Model (SE-AM)

According to Thailand's State Enterprise Policy Office (2023c), the framework for assessing the performance of state enterprises according to the State Enterprise Assessment Model (SE-AM) system is divided into two parts as follows:

- 1. **Key Performance Area**: The first part focuses on the state enterprise's strategic implementation, as well as key results such as the performance of important missions or project plans that reflect efficiency and achievement.
- 2. Core Business Enablers: The second part consists of eight assessment areas: Corporate Governance & Leadership, Strategic Planning, Risk Management & Internal Control, Stakeholder & Customer Management, Digital Technology, Human Capital Management, Knowledge Management & Innovation Management, and Internal Audit.

To create assessment criteria for Knowledge Management (KM) which is a core business enabling factor, the State Enterprise Policy Office (2023c) employed the Triplex Perspectives, which include leadership roles, process, and outcome, to determine the factors affecting the success of knowledge management as illustrated in Table 1.

Perspectives	Criteria	Indicators					
	1. Leading the organization	1.1 Vision / direction / knowledge management policy					
		1.2 Participation of executives at all levels					
	2. Planning and Support	2.1 KM planning and evaluation monitoring					
Leadership	Resources	2.2 Resource allocation					
roles	3. Personnel	3.1 Awareness, understanding, participation and KM					
		incentives					
		3.2 Work culture and environment					
		3.3 Competencies and responsibilities of the KM team					
	4.1 Systematic knowledge management process and						
		application of technology					
Process	5. Operational process	5.1 Knowledge-based operations					
		5.2 Creating knowledge-based operational risk					
		awareness					
Outcome	6. KM outcome	6.1 Results of the performance derived from KM					
Guteonie							

 Table 1. KM Triplex Perspectives

Source: State Enterprise Policy Office (2023c)



Airport Knowledge Management

As this paper focuses on the SE-AM assessment of airport KM, it is crucial to understand how airports around the world have been transformed into state enterprises. As Baxter and Srisaeng (2021) explained, the privatization of airports by governments has been one of the most significant trends in the global airport industry over the past thirty years. Following privatization, airports normally employ a commercial business model to maximize their revenue. By adopting such a commercial management focus, airports in recent times have transformed into a dynamic and competitive industry.

To operate an airport successfully in a competitive environment, KM plays a key role in the airport industry, particularly due to two major factors. Firstly, managing the airport requires specific knowledge for particular job functions. While airport management knowledge can be learned or acquired through experience, Chutiphongdech and Vongsaroj (2022) argued that most employees in Thai airports lack a solid foundation in airport business and airport operation knowledge. Moreover, some airport executives are from non-airport organizations and therefore do not have the relevant background. Secondly, a number of authors (e.g. Almahamid et al., 2021; Linden, 2021) highlighted another factor emphasizing the need for airport knowledge which is COVID-19. As COVID-19 has disrupted the airport industry and created an uncertain environment, managers in the airport industry need to adapt and prepare for future crises by developing more resistant organizations with a greater learning capacity.

With these influential factors, airports should be regarded in the same way as a learning organization (Linden, 2021). By identifying and managing the wealth of knowledge and experience of all employees, airports can create more agile and flexible management which prepares them for any future crises and accelerates the crisis recovery (Lopez-Valpuesta & Casas-Albala, 2023) in order to develop a more resilient organization (Linden, 2021). Whilst there is a wide array of KM implementation strategies, Miao et al. (2022) examined the critical elements of KM in the air transport industry. Findings have revealed that the most important KM implementation approach is information sharing, with joint knowledge creation and E-learning as the second and third most important approaches respectively. In turn, these three KM implementation approaches have a positive influence on management and efficiency performance in the aviation sector.

Research Rationale

As the concept of performance appraisal model has been widely implemented by Thai state enterprises, an analysis of performance practice can provide a practical approach for other state enterprise to learn and follow (Wipulanusat et al., 2016). Nonetheless, there is a lack of study on how Thai state enterprises implement KM, particularly in the airport industry. Therefore, this paper aims to examine how an airport operator, as one of Thailand's largest state enterprises, performs KM based on SE-AM assessment, and to conduct a gap analysis between actual and expected



assessment KM scores. It should be pointed out that this paper has adopted the definition of KM based on a number of authors (e.g. Abdalla et al., 2022; González-Ramos et al., 2023; Li et al., 2023; Mennini et al., 2022; Öberg & Lundberg, 2022; Pepple et al., 2022; Vrontis et al., 2021) as the process of identifying, managing, and sharing knowledge.

Methodology

This paper utilized a qualitative research methodology to explore KM implementation by a stateenterprise airport operator which manages six major airports in Thailand. A qualitative methodology has been applied by a number of authors (e.g. Pepple et al., 2022) to assess KM implementation and the factors that influence their effectiveness. The target population includes executives and employees of the airport operator in Thailand. To better understand the experiences and to obtain a broader picture of the work connected with the SE-AM framework, a purposive sampling method has been used to approach employees who had different levels of involvement in the SE-AM self-assessment process and different levels of responsibility in their jobs. 60 employees were approached and 22 employees (a 36.7% response rate) met the criteria and agreed to participate. As Hennink and Kaiser (2022) pointed out, qualitative studies can reach data saturation at relatively small sample sizes (9-17 participants).

In-depth interviews were conducted during July-August 2022. Each participant was given the following questions for discussion:

- 1. When compared with the actual SE-AM KM score in 2021, what would be the target SE-AM KM score in 2026?
- 2. In order to achieve such a target, which KM strategies or activities should be implemented?

To analyze the data, the content analysis technique was utilized to determine the relationship between the themes that emerged from the interviews. Each theme was color-coded with one color for each theme. Tables were then constructed to identify the themes using Microsoft Excel software. As Buathong and Lai (2017) pointed out, content analysis is considered an appropriate technique for generating valid inferences from texts in the context of their use. To improve the validity of the qualitative data, triangulation has been employed by discussing the overall findings with the respondents via email. In general, the respondents agreed with the findings and did not have further comments.

Results

The respondents were asked to rate each statement concerning their expectations in regard to the SE-AM score in 2026, (i.e. the next five years from the latest score in 2021) using a five-point Likert scale ranging from (1) 'Very low' to (5) 'Very high.' The measurement of their level of expectation and perception was divided into five levels. The class intervals were as follows:

Mean = Highest score – lowest score / Number of levels = (5 - 1) / 5 = 0.80



Actual SE-AM score in 2021

Therefore, the criteria used to interpret the mean score were as follows:

- A score between 1.00 and 1.80 means very low
- A score between 1.81 and 2.60 means low
- A score between 2.61 and 3.40 means moderate
- A score between 3.41 and 4.20 means high
- A score between 4.21 and 5.00 means very high

Table 2. SE-AM gap score

Criteria		Actual SE-AM score in 2021		SE-AM target in 2026		Gap
Leadership roles	1. Leading the organization	2.35	Low	3.80	High	1.50
	2. Planning and support resources	2.50	Low	3.30	Moderate	0.80
	3. Personnel	2.68	Moderate	3.30	Moderate	0.60
Process	4. KM process	3.05	Moderate	3.80	High	0.80
	5. Operational process	2.35	Low	3.00	Moderate	0.70
Outcome	6. KM outcome	1.95	Low	3.00	Moderate	1.10
Average		2.48	Low	3.37	Moderate	0.89

-SE-AM target in 2026



4. KM process

Figure 1. SE-AM gap score



Based on the actual SE-AM assessment score in 2021, the airport operator achieved an average of 2.48 score, with "KM outcome" as the lowest score at 1.95 and "KM process" as the highest score at 3.05. When asked for the expectation for the SE-AM score in 2026, the participants had an average expected score of 3.37 with the largest gaps in "Leading the organization" (1.50 gap score), "KM outcome" (1.10 gap score), "Planning and support resources" and "KM process" (0.80 gap score) respectively. The details are shown in Table 2 and Figure 1 above. Each participant was then asked the following question: "In order to achieve such a target, which KM strategies or activities should be implemented?" Based on content analysis, the themes that emerged in regard to each SE-AM criterion are discussed below.

Leading the Organization

As shown in Table 1, the SE-AM criterion "Leading the organization" consists of two indicators, which are: "Vision / Direction / Knowledge Management policy" and "Participation of executives at all levels." To shift the SE-AM score of 2.35 in 2021 to the expected score of 3.80 in 2026, the respondents recommended the following KM strategies. Firstly, this airport operator needs to encourage KM participation from executives at all levels. One respondent stated that "*Right now our top management has actively communicated the importance of KM; however, the management in the middle level is still primarily focused on day-to-day operations and does not put sufficient emphasis on executing the top management's KM direction."*

To do so, top management should be invited to join the KM working committee, with the committee meeting more frequently in order to communicate the vision from management and to drive outcomes. More importantly, mid-management needs to be able to communicate the benefits of using KM to their employees, which includes how KM could enhance their work efficiency. Secondly, the management team needs to lead by example, to demonstrate their commitment to the KM process. For instance, management can start with a trial executive meeting which allows the employees to observe how the management makes critical decisions based on the available knowledge of the committee.

Planning and Support Resources

The "Planning and Support Resources" criterion consists of two indicators, which are "KM planning and evaluation monitoring" and "Resource allocation." To shift from 2.50 to the 3.30 SE-AM score, the respondents suggested the following. Firstly, the airport operator needs to ensure that its KM plan is up-to-date and is aligned with other major plans, which include an organizational strategic plan to related masterplans such as the innovation masterplan, the human resources masterplan, the digital masterplan, and more. Without alignment with such master plans, it will be very challenging for KM to support the strategies of the organization. Secondly, the airport operator needs to show commitment to KM implementation by setting a policy to allocate the KM budget based on the organization's profit in each fiscal year. One respondent commented that "one of the approaches to show the organization's commitment to KM is to allocate budget,



such as a small percentage from annual profit. This will empower various departments to enhance their own KM, instead of waiting for the HR department to provide one-size-fits-all KM activities". Moreover, the KM team would need to provide a quarterly update on the progress of KM implementation, preferably in an online dashboard format, which can be as simple as a Google Sheet, or with more advanced computer software, such as Power BI.

Personnel

The SE-AM criterion "Personnel" comprises three indicators which are "Awareness, understanding, participation and KM incentives", "Work culture and environment", and "Competencies and responsibilities of the KM team." To improve the SE-AM score from 2.68 to 3.30, the respondents suggested that nurturing a KM culture and atmosphere is very important particularly because most employees perceive KM as a low priority or even a burden. As a result, many employees believe that KM implementation is the responsibility of the Human Resources department despite the fact that KM is an organizational effort. Therefore, the airport operator needs to convey the message through various types of communication channels ranging from formal channels (e.g. email) to informal channels (e.g. messaging mobile app). To create a good KM atmosphere, employees should be motivated through a gamification or incentive system, rather than a KPI system One respondent stated that "Of course KPI is one way of driving KM; however, doing KM should not be all about mind-numbing paperwork. Instead, KM can be a good learning experience which will be a better way to raise the employee's awareness, understanding, and participation towards KM." For instance, those who contribute knowledge could earn points which can be redeemed for a special prize.

KM Process and Operational Process

The "KM process" criterion generally examines the knowledge management process and application of technology, whilst the "Operational process" focuses on knowledge-based operations and risk awareness. To enhance both aspects, the respondents agreed that a digital KM platform is needed, which can be accessed anywhere, at any time, and on any device. Firstly, this platform could be in the format of a mobile app, a web app, or a website, and serves as a one-stop service for those who seek to obtain information regarding the management of the airport, as well as other organizational management topics such as how to streamline work processes.

Secondly, the airport operator should familiarize its employees with KM by integrating KM as part of the work process. For instance, instead of finding information by themselves when developing a new product or work process, employees should start the process by searching for available knowledge on the digital KM platform. Thirdly, the airport operator needs to consider the risks that will affect the KM process, such as the COVID-19 pandemic about which most airport operators had limited knowledge or know how. Another risk involved with KM is the risk of losing intrinsic knowledge due to the employee's retirement or resignation. One respondent stated that *"we have a large number of employees who have worked for this airport operator for over 10*



years. They have acquired tremendous skills and knowledge through their experiences. Therefore we need to learn from them as much as we can to ensure that their unique knowledge can be transferred to others".

KM Outcome

Regarding the "KM outcome" criterion, the airport operator needs to focus on the results of the performance improvement that derive from KM implementation. To improve the SE-AM score from 1.95 to 3.00, it is vital for the organization to enhance key performance with KM implemented as part of the process. To do so, the airport operator could consider reviewing its KPIs to ensure that KM is utilized to drive the KPIs. However, the respondents pointed out that the KM outcome would not be successful without the implementation of other SE-AM criteria discussed above, which range from leadership roles to operational process. Therefore, it is crucial to have a monitoring system, or dashboard, to track the process of KM. One respondent suggested that "there should be a real-time dashboard where the management could monitor the process of KM to ensure that the knowledge crucial to the airport operator has been identified, acquired, managed, and transferred to employees who would benefit from such knowledge".

Conclusion

This paper offers an approach to conducting gap analysis using a State Enterprise Assessment Model (SE-AM). By utilizing a Thai airport operator as a case study, this paper discussed the background and development of a SE-AM model, with KM as one of the core business enablers, issues of knowledge utilization, as discussed in aviation literature have been addressed, and a gap analysis was conducted between actual (2021) and expected (2026) SE-AM assessment of KM scores. The results show that the largest gaps were in the following criteria: "Leading the organization" (1.50 gap score), "KM outcome" (1.10 gap score), "Planning and support resources" and "KM process" (0.80 gap score). To fill such gaps, this paper has provided a wide array of managerial implications which have been highlighted by the respondents, ranging from leadershipdriven strategy, and process-driven strategy, to a proven result of key performance with KM implementation as part of the process. Therefore, this paper has contributed to an important area of research in regard to, 'Thai state enterprise's implementation of KM, particularly in an airport industry context, which still lacks study. Finally, the following areas of research are recommended for future study: 1. Comparing the KM performance in different types of state enterprises in Thailand; 2. Examining value creation by state enterprises through the implementation of KM; and 3. Identifying the critical success factors of a state enterprise's organizational learning approach during COVID-19.



References

- Abdalla, W., Renukappa, S., & Suresh, S. (2022). An evaluation of critical knowledge areas for managing the COVID-19 pandemic. *Journal of Knowledge Management*, *26*(10), 2634-2667.
- Almahamid, S., Al-Jayyousi, O., Alalawi, A., & AlQarny, A. (2021). Knowledge management processes and service innovation: Key insights from Saudi international airports. *International Journal of Innovation and Technology Management*, 18(4). <u>https://doi.org/https://doi.org/10.1142/S0219877021500140</u>
- Baxter, G., & Srisaeng, P. (2021). An assessment of a corporatized airport company revenue streams: Part 1 airports of Thailand aeronautical revenues. *International Journal for Traffic and Transport Engineering*, 11(4), 580 596.
- Buathong, K., & Lai, P. (2017). Perceived attributes of event sustainability in the MICE industry in Thailand: A viewpoint from governmental, academic, venue and practitioner. *Sustainability*, 9(7), 1-20.
- Chutiphongdech, T., & Vongsaroj, R. (2022). Critical components of airport business model framework: Evidence from Thailand. *Sustainability*, *14*(4), 1-17.
- González-Ramos, M., Guadamillas, F., & Donate, M. (2023). The relationship between knowledge management strategies and corporate social responsibility: Effects on innovation capabilities. *Technological Forecasting and Social Change*, 188(2023), 122287.
- Hennink, M., & Kaiser, B. (2022). Sample sizes for saturation in qualitative research: A systematic review of empirical tests. *Social Science & Medicine*, 292(January 202), 1-10.
- Li, B., Wan, J., & Hang, J. (2023). Unveiling the role of knowledge management capabilities in strategic emergency response: insights from the impact of COVID-19 on China's new economy firms. *Journal of Knowledge Management*, 27(1), 47-58.
- Linden, E. (2021). Pandemics and environmental shocks: What aviation managers should learn from COVID-19 for long-term planning. *Journal of Air Transport Management*, 90(2021), 1-12.
- Lopez-Valpuesta, L., & Casas-Albala, D. (2023). Has passenger satisfaction at airports changed with the onset of COVID-19? The case of Seville Airport (Spain). *Journal of Air Transport Management, In Press.*
- Mennini, F., Magni, D., Daniele, L., & Favato, G. (2022). Knowledge management in turbulent times: time-based scenario analysis of vaccinations against COVID-19. *Journal of Knowledge Management*, 26(11), 71-88.



- Miao, M., Zaman, S., Zafar, A., Rodriguez, C., & Zaman, S. (2022). The augmentation of Knowledge Management through Industry 4.0: case of Aviation sector of emerging economy. *Knowledge Management Research & Practice*, 20(6), 893-912.
- Nitikasetsoontorn, S. (2019). Governance mechanism of state enterprises in Thailand: the roles of the board of directors and the firm's performance. *Journal of Asian Public Policy*, *12*(2), 186-205.
- Öberg, C., & Lundberg, H. (2022). Mechanisms of knowledge development in a knowledge ecosystem. *Journal of Knowledge Management*, 26(11), 293-307.
- Pepple, D., Makama, C., & Okeke, J. (2022). Knowledge management practices: A public sector perspective. *Journal of Business Research*, *153*(December 2022), 509-516.
- Rodmorn, C., Porrawatpreyakorn, N., & Nuchitprasitchai, S. (2019). Factors affecting information system management and organizational assessment criteria related to information system management of Thai state enterprises. *Science and Technology RMUTT Journal*, 9(1), 140-154.
- State Enterprise Policy Office. (2023a). About SEPA. https://www.sepo.go.th/sepa/contents/1
- State Enterprise Policy Office. (2023b). Background of the State Enterprise Assessment Model (SE-AM). <u>https://www.sepo.go.th/pes/contents/37</u>
- State Enterprise Policy Office. (2023c). State enterprise assessment model: SE-AM. https://www.tris.co.th/state-enterprise-assessment-model-se-am/
- Vrontis, D., Christofi, M., Battisti, E., & Graziano, E. (2021). Intellectual capital, knowledge sharing and equity crowdfunding. *Journal of Intellectual Capital*, 22(1), 95-121.
- Wipulanusat, W., Sunkpho, J., & Thamsatitdej, P. (2016). Exploring the state enterprise performance appraisal: A case study of metropolitan electricity authority. WMS Journal of Management, 42(2), 67–77.

Author Biography

Kom Campiranon, Ph.D. is an Associate Professor at the Service Innovation Program and the Associate Dean for Academic Affairs & Research at the College of Innovation, Thammasat University. His research and teaching interests cover areas in service design, hospitality innovation, travel technologies, and tourism crisis management. Dr. Kom has published internationally in peer-reviewed journals, books, and conferences. In addition, he also served as the Editorial Board for a number of international journals.

