HHAI 2023: Augmenting Human Intellect
P. Lukowicz et al. (Eds.)

doi:10.3233/FAIA230089

Organizations' Interpersonal Activity Knowledge Representation

Serge SONFACK SOUNCHIO [a,1], Thierry COUDERT [a], Bernard KAMSU FOGUEM [a], Laurent GENESTE [a], Cédrick BELER [a] and Sina NAMAKIARAGHI [a]

[a] *Production Engineering Laboratory/UFTMiP 47, Avenue d'Azereix, BP 1629, 65016 Tarbes Cedex, France*

Abstract. Knowledge is essential for organizations' growth as it allows them to solve problems, make decisions, innovate, and stay competitive. Within organizations, there is, on the one hand, explicit knowledge that is easy to capture, represent, and share. On the other hand, there is tacit knowledge possessed and acquired by individuals during their activities. Unlike explicit knowledge, tacit knowledge is difficult to capture and formalize. Organizations have granted more interest and efforts in representing, sharing, and reasoning from explicit knowledge. However, for tacit personal knowledge, they rely on methods such as meetings, mentoring, questions answering, or interviews which are limited in capitalizing on personal knowledge.

This study elaborates on the construction of interpersonal activity graphs for representing, sharing, and reasoning on organizations' tacit knowledge possessed by individuals. The established graph is based on an extended activity theory framework and an ontology for common semantics. The proposed representation captures tacit knowledge in a graph form, making it shareable while offering means to reason and query it.

Keywords. Interpersonal knowledge, Knowledge graph, Ontology, Knowledge management

1. Introduction

In today's economy, knowledge is an essential though intangible asset that increases organizations' performance and impacts their growth by providing a higher understanding of their practices [16,10]. This knowledge can be explicit, well-defined, and codified and can be shared easily with persons and applications through documentation or encoded rules to support organizations' activities. On the other hand, knowledge can be implicit as an outcome of human internal information processing that results in personal know-how acquired during activities carried out in an organization. Also known as tacit knowledge or personal know-how, it is difficult to codify and share [14].

[1]Corresponding Author: Serge Sonfack Sounchio, sss.sonfack@gmail.com

Capturing and sharing personal knowledge within organizations among persons is paramount because it allows them to permanently store persons' tacit knowledge for the benefit of the organization. For example, inexperienced or novices can use the stored knowledge to learn and ensure service continuity. Besides this, the organization can exploit this knowledge for decision-making. Moreover, storing personal knowledge can avoid knowledge losses in case of retirement, promotion, relocation, or resignation of employees [7]. It also allows organizations to share individuals' experiences without impediments such as time, space, level, job rotation, layoffs, or incompatible moods. Furthermore, access to others' knowledge increases collaboration and improves learning and working performances [6].

Initially, personal knowledge bases are created by individuals and generally cover these individuals' social, behavioural, health, or lifestyle information. This knowledge is mainly for private use, as each person collects and internalizes it during his/her activities for his/her benefit [5]. However, within an organization, people's experiences are expected to be shared to improve everyone's' productivity or effectiveness for tasks assigned to them. As a result, making self-managing personal knowledge for personal use will be a loss for colleagues or the organization to which one belongs since none of them will be able to access this knowledge.
Moreover, if organizations' businesses are driven by artificial intelligence (AI), the use of in-person knowledge sharing will make the AI system's acquisition and use of knowledge challenging; meanwhile, this knowledge is essential for AI system performance [9].

Fortunately, digitalization offers means to acquire and exploit Personal knowledge in many domains, such as social and health, even though it has only been for personalize use.
This study aims to design personal knowledge of individuals within an organization around their activities. This knowledge will benefit both persons and the organization, as it can be used to extract operational, tactical and strategical knowledge necessary for the organization's growth.

To achieve this purpose, the proposed solution uses an ontological representation that links the personal knowledge in an organization. The designed knowledge scheme is based on an extension of the activity theory in other to capture aspects of human knowledge such as know-what, know-where, and know-when. It allows the acquisition of interpersonal knowledge within an organization and makes them shareable.

The remainder of this study is organized as follows. Section 2 presents relevant studies related to personal knowledge representation, section 4 describes the proposed knowledge representation, section 5 presents the discussion on the proposed approach, section 6 is the conclusion of this study.

2. Related work

Personal knowledge representation can be used in various domains, including health. [8] built a personal knowledge graph to improve the detection of suicidal ideation on social

media. The graph used to learn this suicidal ideation is extracted from social media, and its user-centered scheme is made up of nodes such as: personal information, experience node, personality node, post behaviour node, linked to Text, Image, Post Time, emotion expression node, interaction node.

In the domain of dialogs assistance or virtual personal assistance (VPA), a personal knowledge graph (PKG) is used to better understand users' utterances in order to provide answers to personalize questions or enable proactive interactions. This PKG is user-centric and is extracted from user speech, using statistical language understanding on personal assertion classification, relation detection, and slot filling. The resulting graph is used to enhance the user experience for the spoken language understanding (SLU).
Like the previous representation, the representation illustrated by these authors is centered on users, with attributes such as children's names, employment, date, place of birth, and family relations.

Another representation of personal knowledge was elaborated by [11] in the domain of research. The personal research knowledge graph (PRKG) is designed to acquire the researcher's professional activities, as well as shared laboratory resources and fine-grained knowledge items related to his/her research work. The concepts used are attributes of the user-centric graph and can also be linked to each other. To make effective use, PRKG can be populated manually or automatically from information extracted from specialized databases such as ORKG[2] and OpenAlex [3] or from the user conversation with a chatbot.
PRKGs can be used to enhance scholarly engines, conversation agents, and recommendation systems in the research field. However, sharing PRKG can require access control in order to set group members who can read the KG.

Authors [12] in their position paper defined personal knowledge graphs (PKG) as graph structure of information personally related to a user, their attributes, and the relation between them. In this PKG, user information can be related to social life, such as family members and friends, health, education, or hobbies. To enhance the semantics, a PKG is connected to other external domains and general-purpose knowledge graphs. This approach to enhance PKG is also use in the domain of personal health knowledge graph (PHKG) [20,21].
According to these authors, PKG, in general, has a spider shape, is user-centered, includes entities of interest to the user, and integrates external data sources.

3. Proposed approach

3.1. Activity theory

Activity theory is an independent and interdisciplinary conceptual framework originated from philosophy and sociology which essence is the dialectical transformations of in-

[2]https://www.orkg.org/orkg/
[3]https://openalex.org/

dividuals and their communities due to their involvement in an activity [2]. It is based of though that doing precedes thinking, that goals, images, cognitive models, intentions, and abstract notions like definition and determinant grow out of people doing things [3]. Activity theory helps to understand humans' actions or their production of artifacts to achieve an objective in an environment or organization whereby human work within a division of labor is social, cooperative, and collective [17,4].
In the proposed approach, to capture other relevant tacit thoughts, the activity theory is complemented with know-what, know-where and know-when These supplements aid to augment the knowledge space as initially defined by the theory.
The main concepts of this complemented activity theory are [19]:

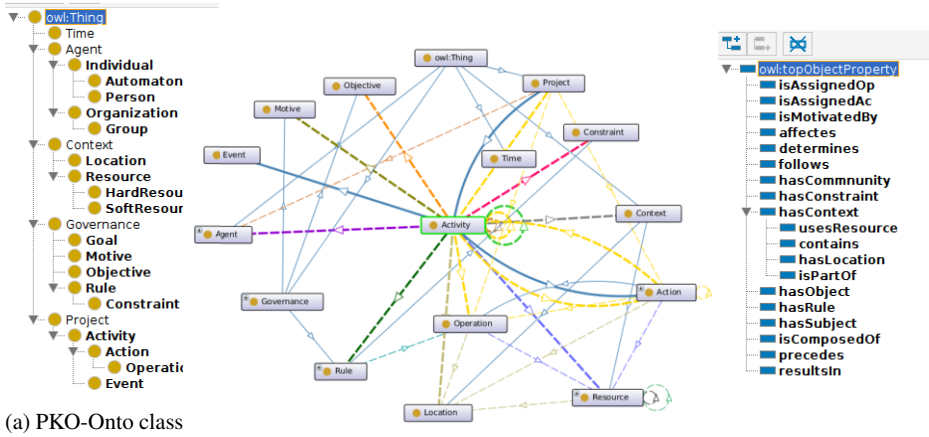
- Subject or Who refers to the agent carrying the activity. A subject can be an individual or a group of actors who perform the activity,
- Rules refers to any regulations, guidelines, codes, heuristics, conventions, laws, norms and cultural practices or policies governing an activity,
- Community refers to the social group to which the subject of the activity belongs. Individuals can simultaneously belong to different communities based their activities,
- Division of labour refers to how the activity is shared and carried out among participants. It includes task division among community members,
- Object or Why refers to the objective or need of the activity. An object is less tangible or intangible such as ideas and provide activity with a direction in a social system,
- Where refers to the geographical region where the activity will or took place,
- Tool refers to supportive resources used by the subject to achieve the activity object. Tools can be physical such as machines or non-physical such as procedure,
- What captures the motivations of the subject(s) for the activity,
- When for condition necessary for the activity to be held.

3.2. Personal knowledge organization ontology

The proposed approach uses a domain-level ontology named the Personal Knowledge Organization Ontology (PKO-Onto) to preserve a common semantic description of activities described by the extended activity theory. The choice of domain ontology allows the extension of concepts to specific application ontology based on the application domain. Figure 1 describes this ontology: the sub-figure 1a shows the concepts hierarchy, Sub-figure 1b shows the graph of concepts and the object properties in Sub-figure 1c. The graph of this ontology shows a high number of relations around the activity concept, which conforms with the activity theory elaborated in the previous section.

3.3. Interpersonal activity graph

An interpersonal activity graph (IAG), as shown in Figure 2, is a graph in nodes are activities are linked to one another if they have the same edge. It relies on the established PKO-Onto ontology constructed on purpose to surrogate the domain knowledge using a methodology from [22]. PKO-Onto integrates general knowledge, such as the wikidata knowledge graph, domain-specific graphs depending on the domain of discussion, such as clinical knowledge graph (CKG) in the medical domain [18], and a resources graph



(a) PKO-Onto class hierarchy for personal knowledge organization

(b) PKO-Onto concepts and relations

(c) PkO-Onto object properties

Figure 1. PKO-Onto Ontology for PKO

in which nodes are resources used in activities and link are relations that exist between them.

There are mainly two types of resources. On the one hand, soft resources from digitalized tools such as files (documents, audio, videos), emails, notes, or chats. On the other hand, hard resources are physical, tangible tools such as cars, tractors, and machines. Soft resources graphs can include communication and collaboration carried out on the organization's social network, an essential means of knowledge exchange among persons within an organization [13]. This graph of soft resources, which can include explicit knowledge, is constructed from person file system organization from their activities [1]. Integrating general and domain-specific knowledge graphs aims to enhance the understanding and reasoning over the IAG.

As a result, IAG is a collective knowledge of individuals that considers multiple aspects of tacit knowledge such as know-how, know-what, or know-who of persons working in an organization. The graph is constructed as a direct connection of activities or connection of activities through their properties such as location, time, subjects, objectives, or rules. Accordingly, it can be used to solve problems, enhance question-answering systems, enterprise wikis, and forums or make decisions for the organization. IAG can also be used by organizations to ameliorate their process by learning rules from the graph [15].

4. Illustration

To illustrate the above model of the interpersonal knowledge graph, the case of teaching activities within a university will be addressed.

The illustration graph concerns two teachers, one teaching database design and the other teaching Python programming. The two teaching activities are carried out in the

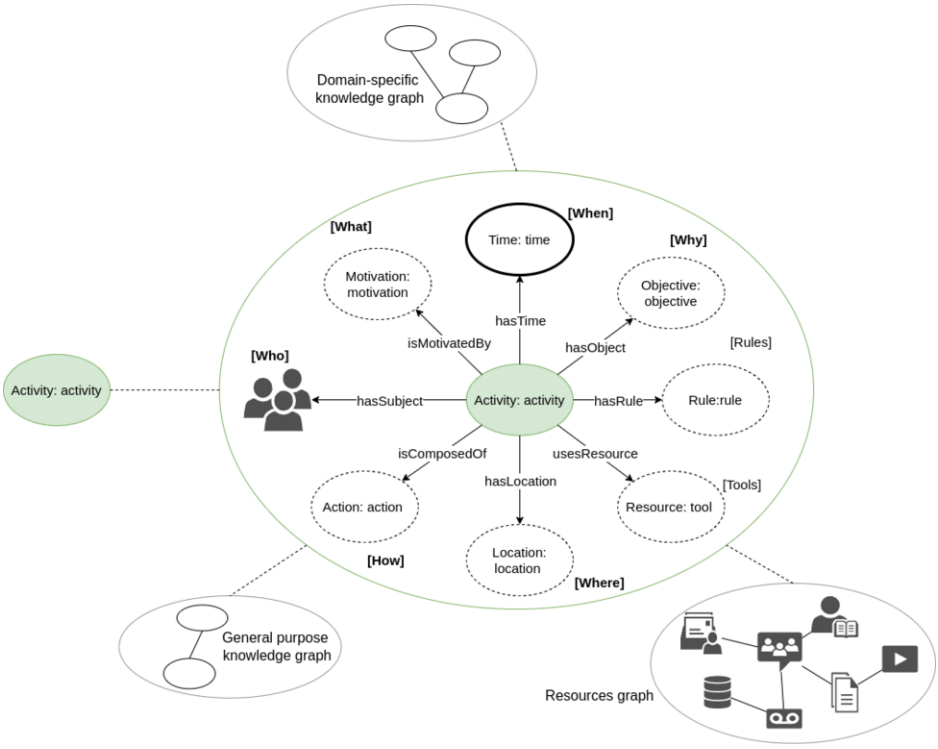


Figure 2. Interpersonal activity graph scheme

same classroom named *Info1* at different times but with the same duration of two hours. Each teacher has a specific file organization for his/her course, but both use markers for their lecture.

The courses' objectives are to teach student database and Python programming. In terms of file system organization, each teacher has a different folder structure. The database teacher puts his/her document directly in the folder named *database books*, while the Python teacher uses two sub-folders for his/her Python codes and books.

For implementation, the established knowledge graph used Wikidata [4] as an external knowledge to enhance the semantics of resources. For example, the resources *MarkerA* or *MarkerB* are *marker pen* used for *writing*. In addition, a person can understand that *Python* is a *programming language*.

This base ontology was also extended to specify concepts such as *Teacher* and the *Teach*ing task and similarly can be extended for other domain of activities.

4.1. Learning from Interpersonal Activity Graph (IAG)

From the above illustration of an IAG, the following questions can be asked with a SPARQL query language:

[4] https://www.wikidata.org/

Block 1: Who knows Python programming

```
PREFIX pko: <http://www.semanticweb.org/serge/ontologies/2022/10/
    pko-onto#>
SELECT DISTINCT ?person ?activityName
WHERE {
                pko:Teach_Py1 pko:hasSubject  ?person.
                pko:Teach_Py1 pko:hasName ?activityName.
        }
```

Block 2: Result of the query in Block 1

```
ic| person: 'T2', activityName: 'Python class level 1'
```

Block 3: What are Python programming resources

```
PREFIX pko: <http://www.semanticweb.org/serge/ontologies/2022/10/
    pko-onto#>
SELECT DISTINCT ?resource ?subresource
WHERE {
                pko:Teach_Py1 pko:hasResource  ?resource.
                OPTIONAL {
                        ?resource pko:contains* ?subresource.
                }
        }
```

- Who has skills or knowledge of activity X?
  The query in Block 1 is an example from the use case to look for persons who know Python programming.
  Block 2 is the result of the query of Block 1. It shows that teach *T2* is the person who carried out activity *Teach_Py1* which is *Python class level 1*.
- What are the resources necessary to carry out X?
  The query in Block 3 bellow is an example from the illustrated case to find resource for Python programming. Block 4 is the result of the query in Block 3. It shows resources used to carry out activity *Teach_Py1*. The result print out documents including folders and sub-folder of this activity.
- Other questions can be related to goals and activities

Similarly, queries can be carried out with the intention of rules or processes. For example, one can be interested in rules that govern a given activity. Queries can also be used to find sub-activities of a given activity.

Block 4: Results of query in Block 3

```
ic| resource: 'markera', subresource: 'markera'
ic| resource: 't1folder00', subresource: 't1folder00'
ic| resource: 't1folder00', subresource: 't1folder10'
ic| resource: 't1folder00', subresource: 'python_programming'
ic| resource: 't1folder00', subresource: 't1folder01'
ic| resource: 't1folder00', subresource: 'learning_python'
```

5. Discussion

This study provides an approach to represent and share personal knowledge within an organization to benefit the person who created it and others in the organization. The approach, unlike existing representation, is not centered on humans/users personal knowledge (personal information, social information, health information) but on their activities. In other words, the proposed activity-centered approach aims to capture knowledge people use to carry out activities. On purpose, no interest is granted to users' interests, such as their social life, family, hobbies, or health, because these pieces of information can be assimilated into private information and do not add value to the knowledge of activities.

From the research study in the previous section, personal knowledge representations are centered on the user and could have links with other knowledge bases. These user-centered representations do well in some application domains as they capture, in general, the social and private environment of the user involved. However, these approaches are not appropriate for personal knowledge in terms of organizations' activities or tacit practical knowledge.

6. Conclusion

This study elaborates on the representation of interpersonal knowledge for externalization and sharing of individuals' experiences within organizations. It relies on the hierarchical activity theory framework extended to capture specific knowledge and complemented with a domain-level ontology designed for shared semantics.
The established approach of externalizing interpersonal knowledge through activity theory framework and semantic technologies offers a shared and interconnected knowledge environment from which individuals within an organization can learn from others using queries to improve their effectiveness and productivity. The knowledge learned from others' activities is used to alleviate activities from which others will learn in return.

In future studies, the proposed knowledge representation will be used to extract specific knowledge needed by three main groups of employees within organizations. These upcoming studies will concern the extraction of operational knowledge for operators to support production, tactical knowledge for managers to optimize processes and techniques, and strategical knowledge for top managers to reduce risks and increase effectiveness.

References

[1] Schröder, M., Jilek, C. & Dengel, A. A Human-in-the-Loop Approach for Personal Knowledge Graph Construction from File Names. *Third International Workshop On Knowledge Graph Construction*. (2022)

[2] Loc, N., Oanh, N., Thao, N., Van De, T. & Others Activity theory as a framework for teaching mathematics: An experimental study. *Heliyon*. **8**, e10789 (2022)

[3] Hashim, N. & Jones, M. Activity theory: A framework for qualitative analysis. (2007)

[4] Gonçalves, A., Sousa, P. & Zacarias, M. Using DEMO and activity theory to manage organization change. *Procedia Technology*. **9** pp. 563-572 (2013)

[5] Zhiyin, Y. & Jiakun, H. Research on Personal Knowledge Management under Web 2.0 Environment. *2017 7th International Conference On Social Network, Communication And Education (SNCE 2017)*. pp. 675-679 (2017)

[6] Jing, L., Yahui, S., Ning, Z. & Xin, L. The design of students-oriented personal knowledge management system. *Physics Procedia*. **24** pp. 2310-2313 (2012)

[7] Sumbal, M., Tsui, E., Cheong, R. & See-to, E. Critical areas of knowledge loss when employees leave in the oil and gas industry. *Journal Of Knowledge Management*. (2018)

[8] Cao, L., Zhang, H. & Feng, L. Building and using personal knowledge graph to improve suicidal ideation detection on social media. *IEEE Transactions On Multimedia*. (2020)

[9] Olan, F., Arakpogun, E., Suklan, J., Nakpodia, F., Damij, N. & Jayawickrama, U. Artificial intelligence and knowledge sharing: Contributing factors to organizational performance. *Journal Of Business Research*. **145** pp. 605-615 (2022)

[10] Jallow, H., Renukappa, S. & Suresh, S. Knowledge management and artificial intelligence (AI). *ECKM 2020 21st European Conference On Knowledge Management*. pp. 363 (2020)

[11] Chakraborty, P., Dutta, S. & Sanyal, D. Personal Research Knowledge Graphs. *Companion Proceedings Of The Web Conference 2022*. pp. 763-768 (2022)

[12] Balog, K. & Kenter, T. Personal knowledge graphs: A research agenda. *Proceedings Of The 2019 ACM SIGIR International Conference On Theory Of Information Retrieval*. pp. 217-220 (2019)

[13] Razmerita, L., Kirchner, K. & Sudzina, F. Personal knowledge management: The role of Web 2.0 tools for managing knowledge at individual and organisational levels. *Online Information Review*. **33**, 1021-1039 (2009)

[14] Mahura, A. & Birollo, G. Organizational practices that enable and disable knowledge transfer: The case of a public sector project-based organization. *International Journal Of Project Management*. **39**, 270-281 (2021)

[15] Omran, P., Taylor, K., Mendez, S. & Haller, A. Active knowledge graph completion. *Information Sciences*. **604** pp. 267-279 (2022)

[16] Hernández, A., Velazco, J. & Luzardo, M. Society of Knowledge and ICT skills in Universities. *Procedia Computer Science*. **210** pp. 363-367 (2022)

[17] Albusaidi, S. Using Activity Theory to explain how a student learns in an internationalised classroom from a sociocultural perspective. *Journal Of Language Teaching And Research*. **10**, 1142-1149 (2019)

[18] Santos, A., Colaço, A., Nielsen, A., Niu, L., Strauss, M., Geyer, P., Coscia, F., Albrechtsen, N., Mundt, F., Jensen, L. & Others A knowledge graph to interpret clinical proteomics data. *Nature Biotechnology*. **40**, 692-702 (2022)

[19] Iyamu, T. & Shaanika, I. The use of activity theory to guide information systems research. *Education And Information Technologies*. **24** pp. 165-180 (2019)

[20] Shirai, S., Seneviratne, O. & McGuinness, D. Applying personal knowledge graphs to health. *ArXiv Preprint ArXiv:2104.07587*. (2021)

[21] Haussmann, S., Seneviratne, O., Chen, Y., Ne'eman, Y., Codella, J., Chen, C., McGuinness, D. & Zaki, M. FoodKG: a semantics-driven knowledge graph for food recommendation. *The Semantic Web–ISWC 2019: 18th International Semantic Web Conference, Auckland, New Zealand, October 26–30, 2019, Proceedings, Part II 18*. pp. 146-162 (2019)

[22] Sonfack Sounchio, S., Kamsu-Foguem, B. & Geneste, L. Construction of a base ontology to represent accident expertise knowledge. *Cognition, Technology & Work*. pp. 1-19 (2023)