Knowledge management technologies for a n-layered architecture

Luciano Straccia, Ma Florencia Pollo-Cattaneo and Adriana Maulini

Grupo de Estudio en Metodologías de Ingeniería en Software (GEMIS), Universidad Tecnológica Nacional Facultad Regional Buenos Aires, Buenos Aires, Argentina

Abstract

Many studies related to Knowledge Management analyze the technologies for its implementation. However, the effective use of technologies and their success, based on Software Engineering concepts, requires their implementation in a clear, precise and well-defined architectural framework. This paper presents knowledge management architectures based on layers, shows technologies surveyed in academic works and analyzes and categorizes these technologies according to the de-fined architectural layers: presentation, access and authorization, knowledge management, taxonomy and knowledge maps, information management and repository.

Keywords

Knowledge Management, KMS, Architecture, N-Layered

1. Introduction

Knowledge is one of the most important strategic resources in the organization. An efficient management of this resource allows to obtain competitive advantages, then Knowledge Management (KM) is of vital importance. Several researchers have proposed models for its implementation, their activities and their related technologies. This paper presents knowledge management architectures based on layers, shows technologies surveyed in academic works and analyzes and categorizes these technologies according to the defined architectural layers.

This paper presents the concepts of Knowledge and Knowledge Management (2.1) and the views for KM models (2.2). Then, different models of KM architectures are presented (3.2), with special emphasis on layered architectures (3.3). In addition, the technologies proposed for KM processes in recent disciplinary literature are reviewed (4). Finally, an analysis of the technologies is proposed, relating them with the layers to which they can be associated (5).

ICAIW 2021: Workshops at the Fourth International Conference on Applied Informatics 2021, October 28–30, 2021, Buenos Aires, Argentina

lstraccia@frba.utn.edu.ar (L. Straccia); fpollo@frba.utn.edu.ar (M. F. Pollo-Cattaneo); adri.maulini@gmail.com (A. Maulini)

2. Knowledge Management

2.1. Introduction

Shannon [1] and Weaver [2] introduced the concepts of data and information. Timpson [3] resume their ideas; he considered the data as a representation of a fact isolated, out of context; and information as collection of data structured in one context (data with meaning). The notions of data and information were incorporated into the DIKW Hierarchy, presented by Ackoff. The DIKW Hierarchy (see Figure 1) presents a hierarchical chain in that each concept adds value to the previous; in the lowest level is found the data; one higher level, information; then, knowledge and in the superior level, the wisdom [4, 5].

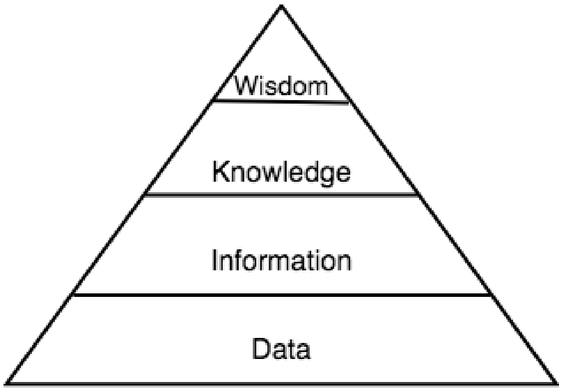

Figure 1: DIKW Hierarchy

Cornella [6] says that transform information into insights produce knowledge in the people minds, generating structure and making sense [7]. The knowledge is a “appropriate and persistent response to a given input” [8] and his value is associated with his use. Finally, “if the knowledge is subjected to judgment value and it gives an ethical context, becomes wisdom " [9].

Díaz et al., [10] define the knowledge as: "the mixture of cognitive and contextualized beliefs, perspectives, judgments, methodologies, information, experiences and expectations about an object, which is adapted and empowered by the people mind". Martínez Rueda [11] proposes that the knowledge provides the basis for generate a critical view of the environment. That is, the environment can be understood and interpreted through to knowledge.

Knowledge Management (KM) is a process to through of the which the organizations can discover, use and maintain the knowledge, for align it to the business strategies and to obtain competitive advantages [11]. Perez et al., [12] define the KM as an emerging discipline for exploit the knowledge generated to achieve the organizational objectives and optimize the process of decision making".

2.2. Knowledge management views

For Gómez-Vargas et al., [13], the Knowledge Management is supported by four components: people, processes, content and I&C (information and communication) technologies [14, 15, 16]. These components match with the considered in [17]: people (roles and responsibilities, motivation, incentives), technology, processes and content. The notion of "content" is similar to “content representation” and its methods [18]. Milton [19] define the follow KM drivers: roles and responsibilities; process; governance (policies, metrics and incentives) and technologies.

According to Zytniewski [20] and Meier [21], in order to be successful in managing knowledge in organizations, it’s necessary to consider the organizational, social and technical aspects. The organizational aspects are also present in Basit et al., [22], Cumberland and Githens [23] and Wahda [24], who consider it is relevant to include organizational culture, also called “institutional aspects” by Sobolewska et al., [25].

Basit et al., [22] presented an investigation, based on Brooke et al., [26] and Park et al., [27], where it is concluded that employee trust is a prerequisite for sharing knowledge. Saavedra et al., [28] consider culture as a relevant factor.

For Wigg [29], an organization capable of creating, acquire and transfer knowledge, must hire people willing to learn. Nonaka et al., [30] also consider some aspects that the organization must support in the knowledge conversion process: organizational commitment, autonomy at all levels, flexibility, redundancy (repeated knowledge throughout the organization) and demand for diversity of personnel and knowledge.

In this paper, the components or dimensions are referred to as "views". Straccia et al., [31] resume the possible views, based on Gomez et al., [13], Barceló [32], Meneses [18] and Milton [19]. The fundamental views for KM are people role and responsibilities, organizational culture (and others organizational topics), process (or activities), governance, knowledge representation and technologies.

3. Knowledge management architecture

3.1. Introduction

The architecture constitutes "a relatively small and intellectually accessible model of how the system is structured and the way its components work together" [33] and show early decisions, which will have a profound effect on all subsequent software engineering work and on the success of the system as an operational entity [34, 35]. An architecture is a system model within a specific context, representing the components necessary to develop the system from a particular perspective or point of view. A system architecture includes the structure of the core components, their characteristics or properties, as well as the relationships and interfaces between the components and external entities [36].

3.2. KM architecture

According to Medina et al., [37], the architectures for Knowledge Management Systems can be divided from two approaches: classical architectures and proprietary architectures. Proprietary architectures are structured with a strong component of agents and are related with proprietary software with their consequent integration and dependency. Classical architectures are considered generic and can be applied to all types of Knowledge Management System and their architectural style is N-Layered, organized by layers that communicate to complete the required functionality; each layer has a well-defined scope and functionality.

Woods et al., [38] present a seven-layer KM architecture with these layers: application, interface, KM services, taxonomy and knowledge maps, process and information management, infrastructure and data source. This model is used for Lawton [39] too and is called Ovum.

Tiwana [40] proposes a new seven-layer KM architecture: interface, access and authentication, collaborative filtering and intelligence, application, transport, legacy integration middleware integration and repository.

One of the main knowledge management models is the Kerschberg Model, which proposes a technological architecture for knowledge management defined by three layers: knowledge creation and presentation, knowledge management and data source [41]. Zavala Zavala [42] and Jofré et al., [43] present other models of technology integration architecture based on the Kerschberg model, with the same layers.

Finally, Moscoso [44] proposes a hybrid infrastructure for intelligence, business analysis and knowledge management based on an educational data warehouse (EDW) and an enterprise architecture repository (EA) that allows the digitization of knowledge for the visualization and analysis of organizational components. The main components of its infrastructure proposal are a software tool for modeling organizational components, an EDW (Educational Data Warehouse), OLAP tools, EDM software and visualization tools. However, unlike the other architectures, it does not use a layered model, which is the scope of this work.

3.3. N-layered architecture

In the previous section different architectures were presented, identifying three layered models: Ovum, Tiwana and Kerschberg. In this section these models are analyzed and compared. When knowledge management architecture models are analyzed comparatively with 3-layer software programming models, some similarity can be found. The 3-layer software architecture models have the following layers: User Interface (UI), Application Logic and Database (or Data) [45], as shown in (see Figure 2).

Figure 2: Layers in 3-layer software architecture

The 3 models match in proposing a presentation layer; although in Ovum, it is subdivided according to the characteristics of the applications, reserving a first layer for applications in general, while proposing a second layer exclusively for the knowledge portal.

Regarding the lower-level layers, all models also coincide in the existence of a repository and data source layer, although Tiwana incorporates some technical aspects of networks and hardware as a transport layer and Ovum proposes an infrastructure layer, aspects that are not considered in this paper because they are considered out of its scope [46].

For this work, Kerschberg's nomenclature is used: Presentation and Repository, respectively.

In the models presented, there are some differences with respect to the intermediate layers (see Figure 3). Ovum proposes the following layers: Knowledge Management, Taxonomy and Knowledge Maps and Process and Information Management. Tiwana opts for two layers: Collaborative Filtering and Intelligence and Application. Finally, Kerschberg incorporates everything in a single layer.

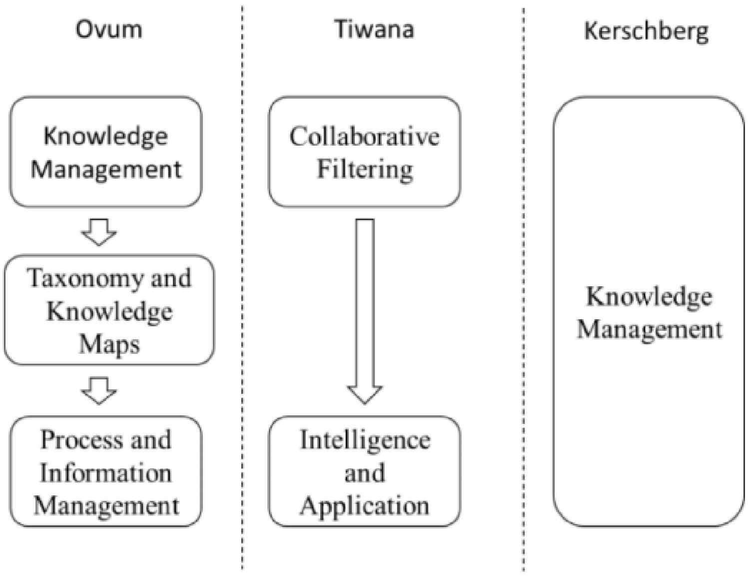

Figure 3: Intermediate Layers in N-Layered Architecture

Considering that Ovum's architecture is the most detailed, this paper considers its 3 levels for the present work. In addition, Tiwana innovates with the proposal of an access and authentication layer that is later used in [47]. The resulting model can be seen in (see Figure 4).

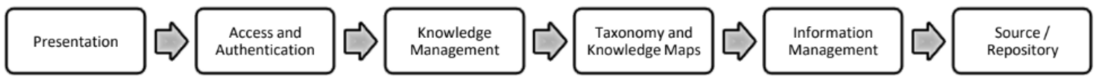

Figure 4: Layers in N-layer Knowledge Management Architecture

4. Knowledge management technologies

4.1. Introduction

Without attempting to constitute a systematic review of the literature, but following an orderly search process, a search was conducted on various knowledge management articles that propose

Table 1
Support tools for KM according [50]

Tools related to KM	Types of tools
E-learning	Video streaming, online forums, curricular nets, LMS.
Repositories	Knowledge base, question and answer bank, datawarehouse, expert systems.
Corporate intranets	Survey systems, content management, user profiling systems, visits statistics.
Collaboration tools	Wiki systems, chats, collaborative forums, blogs, mailing systems.
Intelligent agents	Search engines, management reports systems, talent management, multidimensional cube.
Customer intelligence	CRM, customer database.
Process management	Online manuals, procedural bases, workflows, RSS.
Collaborative platform	Expert guides, CMS, ECM.

technologies. A search is performed on the Association for Computing Machinery (ACM), the Institute of Electrical and Electronic Engineers (IEEE), Directory of Open Access Journals (DOAJ) and Science Direct. For the first sources the search is performed on the year 2019, while in Science Direct the search corresponds to the years 2017 and 2018. The findings of these searches are presented below.

4.2. Technologies

For Jin-Feng et al., [48], the information technology should include "Internet, intranet, extranet, mobile network, browser, data storage, data mining technology, software agents, network community, cloud platform" and open platforms such as Baidu, Wikipedia or Zhihu, which are referred to as wiki in this work.

Paschek et al., [49] present a model of KM parallel to the Business Process Man-agement (BPM), highlighting the importance of managing knowledge in parallel to business management to adapt to the constant changes in the organizations. The authors propose the following technologies: Big Data, cloud apps, Datawarehouse and Business Applications.

Córdova et al., [50] show the implementation of KMS and states that "technology adapts to organizational structures and needs, providing support tools for knowledge management, through the interaction and use of collaborative tools". The proposed knowledge management support tools are classified in Table 1.

Wamuyu et al., [51] say that "to support knowledge sharing among the County Government employees, counties should deploy knowledge sharing systems such as collaborative systems and knowledge repositories to allow the employees to acquire tacit and explicit knowledge from each other". However, it does not provide significant technology-related details.

Roblek et al., [52] show an analysis about the smart city knowledge management. They present different KM views, including the technologies. The work recommended the data collection and exchange through information technologies components and devices which are connected on the internet or wireless, big data management and artificial intelligence applications. Then, the authors propose use platforms such as e-health, e-gov, e-learning, e-social connections for seniors, e-mobility.

Bongku et al., [53] compare Knowledge Management Applications: OpenKM, Alfresco and XWiki, based in several criterial. Alenezi et al., [54] discuses about the use of ontologies for KM specific to soft-ware security. Although it shows ontologies, most of the paper compare specific technologies like OntoCheck, RDF Triple, OOPS.

Liu [55] researches on Knowledge Management Technology of Aerospace Engineering Based on Big Data and shows the Hadoop architecture. Hadoop is a distributed system infrastructure developed by Apache Foundation and implements a Distributed File System. The author shows a framework of Knowledge Management with activities and technologies.

Hibbi et al., [56] show an expert model with a Bayesian Network method. This model proposes process knowledge to combine three categories of knowledge: Declarative, Procedural and Conditional and shows an Intelligent Tutoring System (ITS) that includes Instructional Module, Expert Module, Implicit and Explicit tutors, Pedagogical Agents and Collect Data resources. Tseng et al., [57] show a study that provides valuable findings regarding the possible causal relationships among social media use, Knowledge Management Capability (KMC) and supply chain agility. The results indicate that social media use have an indirect influence on supply chain agility through the mediation of KMC.

Other papers use some aspects of KM and propose some tools: Ismail et al., [58] analyze the social presence in digital community and propose use of Agent-Mediated Personal Knowledge Management and Ferchichi et al., [59] propose an ontological rule-based approach for software product lines evolution and present use of Protégé OWL and SWRL.

Cerchione et al., [60] provide a literature review of how knowledge management is applied in SMEs. It analyzes different articles and present the followings: tools that support the creation phase, tools that support the storage phase, tools that support the transfer phase, practices that support the creation phase, practices that support the storage phase, practices that support the transfer phase. The result is a detailed taxonomy presented in Table 2 where the tools and practices that support each of the phases of the KM process are included.

A few authors present technologies with some architectonic relationship. Xiaohua [61] recover the seven-layer architecture KM and propose some technologies for three layers:

- in the collaborative filtering and intelligence layers propose intelligent agent tools, content personalization, querying, indexing and metatags;
- in the application layer the works proposes skills directory, yellow pages, collaboration tools, video conferencing, digital whiteboards, electronic forums, DSS (Decision Support Systems) and GDSS (Group Decision Support Systems); and
- in the repository layer proposes legacy systems, datawarehouse, forum, document library, storage and others (without details about others).

Among the authors previously presented, Kerschberg [41] also presents some tools to consider for each layer:

Table 2
Taxonomy of KM-Tools according [60]

KM-Phase	Tools
Knowledge creation	Data mining, data visualization, expert systems, social data mining, text mining, collaborative filtering, crowdsourcing systems, mash-up, prediction and idea, markets, syndication systems, trust and reputation systems.
Knowledge storage	Business process management systems, configuration management systems, content management systems, product data management systems, product lifecycle management systems, ERP, datawarehouse, decision support systems.
Knowledge transfer	Cloud computing, learning management systems, peer-to-peer resource sharing, podcasting/videocasting, social media, wiki, audio conference/video conference, blogs, chat, conversational technologies, email.

- Presentation: knowledge portal, search services, collaboration and messaging service, videoconference service, discussion group service and knowledge creation service.
- Knowledge management: data mining services, metadata tagging, ontology and taxonomy, workflow.
- Knowledge management for information integration services: data warehouse, federation services, agent services, mediation services, security services.
- Repository: web repository, emails repository, domain repository, text repository and media repository.

5. Technologies in KM architecture

In this section, the technologies collected are assigned to each layer. The layers considered for this work, already presented in 3.3 and in Figure 4, are: Presentation, Access and Authentication, Knowledge Management, Taxonomy and Knowledge Maps, Information Management and Source / Repository.

First, the technologies of architecture-oriented works are considered [41, 50, 61]. The tools of the collaborative filtering and intelligence layer propose for Xiaohua are considered in KM layer. The tools of the repository layer are assigned in the layer of the same name. The author considerer the application layer as "tools enable the integration of information, including implicit sources of information (for example: people) and explicit sources of knowledge (for example: databases, transaction storage and data warehouses, etc.), helping to create and share context to facilitate make judgments, such as brainstorming sessions, problem solving, idea generation, and strategic planning meetings". For the analysis of this paper, some of the tools are considered by other authors in the presentation layer and for others in the repository layer, so it is decided to analyze each tool individually later in this paper.

Kerschberg proposes technologies for the presentation layer, knowledge management and repository, as well as the N-Layered model considered for the analysis, except "ontology and taxonomy" which is considered for the specific layer in this work. The fourth layer of Kerschberg are considered in the detailed analysis presented below.

Cerchione presents a knowledge creation phase on which he presents several tools. These tools can be included in the Knowledge Management layer, which is responsible for these activities. Meanwhile, knowledge transfer implies an interaction between knowledge management actors and therefore the tools reserved for this activity are incorporated in the presentation layer.

Some of the tools proposed by Cordova can also be linked to the proposed layers: intelligence agents are knowledge management processes (KM Layer), collaboration tools are presentation tools and proposes an assimilable layer: repositories. Then, the match between [41, 50, 61] and the N-layered are:

- Presentation: knowledge portal, search services, collaboration and messaging service, videoconference service, discussion group service and knowledge creation service (from Kerschberg); wiki systems, chats, collaborative forums, blogs, mailing systems (from Cordova); cloud computing, learning management systems, peer-to-peer resource sharing, podcasting/videocasting, social media, wiki, audio conference/video conference, blogs, chat, conversational technologies, email (from Cerchione);
- Knowledge management: agent tools, content personalization, querying, indexing and metatags (from Xiaohua); data mining services, metadata tagging, workflow (from Kerschberg); search engines, management reports systems, talent management, multidimensional cube (from Cordova); data mining, data visualization, expert systems, social data mining, text mining, collaborative filtering, crowdsourcing systems, mash-up, prediction and idea, markets, syndication systems, trust and reputation systems (from Cerchione);
- Taxonomy and knowledge Maps: ontology and taxonomy (from Kerschberg).
- Repository: legacy systems, datawarehouse, forum, document library (from Xiaohua), web repository, emails repository, domain repository, text repository and media repository (from Kerschberg); knowledge base, question and answer bank, datawarehouse, expert systems (from Cordova).

The remaining technologies in the different papers are presented without assignment to any layer, so they are analyzed. First, technologies already incorporated in some layers are eliminated, as are aspects of resources (network, peer-to-peer resource).

Some applications such as Business Process Management Systems, Configuration Management Systems, Content Management Systems, Product Data Management Systems, Product Lifecycle Management Systems, ERP, Decision Support Systems (tools presented from Cerchione), LMS, ECM, Content Management, CRM, platforms (such as e-health, e-gov, etc.) [62, 63, 64], Knowledge Management Application (Open KM, Alfresco, XWiki), RSS, Intelligent Tutoring System, Business Applications or cloud apps are not feasible to incorporate in a single layer and must be analyzed in detail in the architecture of each software. They could be called multilayer software [65].

The different technologies collected not assigned to any layer are presented in Table 3.

From the resulting list, security services correspond to the Access and Authentication layer. Technologies involving user interaction are identified and incorporated into the presentation

Table 3
Technologies not assigned to any layer

Authors	Tools
Feng et al., [48]	Internet, intranet, extranet, mobile network, data storage, network community, cloud platform.
Paschek et al., [49]	Big data.
Cordova et al., [50]	Video streaming, curricular nets, survey systems, user profiling systems, visit statistics, customer database, online manuals, procedural bases, RSS, expert guides.
Xiaohua [61]	Skills directory, yellow pages, collaboration tools, digital whiteboards.
Kerschberg [41]	Federation services, mediation services, security services.

layer: collaboration tools, digital whiteboards, yellow pages and survey system. For the repository layer can be identified: online manuals, procedural bases, curricular nets, skills directory, customer database, data storage, internet, intranet, extranet and expert guides. Meanwhile, the knowledge management layer can include big data, and text mining.

The user profiling systems or visits statistics can be included in Information Management layer. The federation services and mediation services are proposed from Kerschberg as an integration services between the repositories and the KM layer. For the N-layered architecture at this paper, this role is presented in Information Management layer too.

6. Conclusions

There are several architectures for knowledge management. Most of them are N-Layer architectures. This paper proposes a 6-layer architecture: Presentation, Access and Authentication, Knowledge Management, Taxonomy and Knowledge Maps, Information Management and Source / Repository.

Then, different technologies proposed in different works are analyzed and assigned to the corresponding layers, resulting:

- Presentation: knowledge portal, search services, collaboration and messaging service, videoconference service, discussion group service and knowledge creation service, wiki, chats, collaborative forums, blogs, mailing systems, cloud computing, Learning Management Systems, peer-to-peer resource sharing, podcasting, videocasting, social media, wiki, audio conference, conversational technologies, email, collaboration tools, digital whiteboards, yellow pages and survey system.
- Access and authentication layer: security services.
- Knowledge management: agent tools, content personalization, querying, indexing and metatags, data mining services, metadata tagging, workflow, search engines, Management Reports Systems, talent management, multidimensional cube, Data Mining, data visualization, expert systems, social data mining, text mining, collaborative filtering,

crowdsourcing systems, mash-up, prediction and idea, markets, syndication systems, trust and reputation systems, big data, and text mining.
- Taxonomy and Knowledge Maps: ontology and taxonomy.
- Information management: profiling systems, visit statistics, federation services, mediation services.
- Repository: legacy systems, datawarehouse, forum, document library, web repository, emails repository, domain repository, text repository and media repository, knowledge base, question and answer bank, datawarehouse, expert systems, online manuals, procedural bases, curricular nets, skills directory, customer database, data storage, internet, intranet, extranet and expert guides.

Some applications are multilayer are not feasible to incorporate in a single layer and must be analyzed in detail in the architecture of each software.

References

[1] C. E. Shannon, A mathematical theory of communication, The Bell system technical journal 27 (1948) 379–423.
[2] W. Weaver, Recent contributions to the mathematical theory of communication, ETC: a review of general semantics (1953) 261–281.
[3] C. G. Timpson, Quantum information theory and the foundations of quantum mechanics, OUP Oxford, 2013.
[4] O. Lombardi, F. Holik, L. Vanni, What is shannon information?, Synthese 193 (2016) 1983–2012.
[5] R. L. Ackoff, From data to wisdom, Journal of applied systems analysis 16 (1989) 3–9.
[6] A. Cornella, Cómo sobrevivir a la infoxicación, Infonomia. com 8 (2000).
[7] P. Checkland, S. Holwell, Information, systems, and information systems, John Wiley & Sons Chichester, 1998.
[8] J. Sanders, Defining terms: Data, information and knowledge, in: 2016 SAI Computing Conference (SAI), IEEE, 2016, pp. 223–228.
[9] M. Pollo-Cattáneo, Resolviendo problemas en los sistemas de información: enfoque para informáticos, Centro de Estudiantes de Ingeniería Tecnológica, CEIT (2012).
[10] M. T. Rodríguez Díaz, J. J. González Millán, Gestión del conocimiento y capital intelectual, a través de modelos universitarios, ECONÓMICAS CUC (2013).
[11] E. Bueno, Dirección del conocimiento y aprendizaje: creación, distribución y medición de intangibles, Instituto Universitario Euroforum Escorial. Madrid (1999).
[12] V. A. Pérez, M. F. Urbáez, Modelos teóricos de gestión del conocimiento: descriptores, conceptualizaciones y enfoques, Entreciencias: diálogos en la Sociedad del Conocimiento 4 (2016) 201–227.
[13] M. Gómez-Vargas, M. García Alsina, Factores influyentes de la gestión del conocimiento en el contexto de la investigación universitaria, Información, cultura y sociedad (2015) 29–46.
[14] R. Seethamraju, O. Marjanovic, Role of process knowledge in business process improvement methodology: a case study, Business Process Management Journal (2009).

[15] G. D. J. O. Carlos, Conocimiento y gestión, Editorial Pearson Educación. SA Madrid (2004).
[16] A. Canals, La gestión del conocimiento, 2003.
[17] A. Baglietto Tardio, M. Barceló Llauger, et al., Hacia una economía del conocimiento, Madrid: Esic (2001).
[18] J. P. Meneses-Ortegón, T. Jové, J. Puiggalí, R. Fabregat, Representación del conocimiento de un proceso de co-creación de material educativo, TecnoLógicas 23 (2020) 156–174.
[19] N. Milton, The 4 legs on the knowledge management table, Recuperado: http://www.nickmilton. com/2014/10/the-4-legs-on-knowledge-management-table. html (2014).
[20] M. Żytniewski, Integration of knowledge management systems and business processes using multi-agent systems, International Journal of Computational Intelligence Studies 5 (2016) 180–196.
[21] R. Maier, Information and communication technologies for knowledge management, Vol (2007) 125.
[22] A. Basit, T. F. Qazi, A. A. K. Niazi, Expounding dynamics of tacit knowledge critical to credit decision making: Juxtaposed findings of gra and ridit, Journal of Accounting and Finance in Emerging Economies 6 (2020) 87–106.
[23] D. Cumberland, R. Githens, Tk barriers in franchising: Practical solutions, Journal of Workplace Learning 24 (2012) 48–58.
[24] W. Wahda, Mediating effect of knowledge management on organizational learning culture toward organization performance, Journal of Management development 36 (2017) 846–858.
[25] O. Sobolewska, A. Bitkowska, Selected aspects of evaluating knowledge management quality in contemporary enterprises, Information 11 (2020) 244.
[26] J. Brooke, R. M. Rasdi, B. A. Samah, Modelling knowledge sharing behaviour using self-efficacy as a mediator, European Journal of Training and Development (2017).
[27] J.-G. Park, J. Lee, Knowledge sharing in information systems development projects: Explicating the role of dependence and trust, International Journal of Project Management 32 (2014) 153–165.
[28] J. Saavedra, D. V. Y. A. Lacruz, Gestión del conocimiento, Tomado de http://www. gestiondelconocimiento. com 8 (2002).
[29] K. M. Wiig, Knowledge Management Foundations: Thinking about Thinking-how People and Organizations Represent, Create, and Use Knowledge, Schema Press, Limited, 1994.
[30] I. Nonaka, H. Takeuchi, The knowledge-creating company: How Japanese companies create the dynamics of innovation, Oxford university press, 1995.
[31] P. Gerlero, L. Straccia, M. F. Pollo Cattaneo, Marco de trabajo para la gestión del conocimiento en la administración de proyectos de desarrollo del software, in: XXIII Workshop de Investigadores en Ciencias de la Computación (WICC 2021, Chilecito, La Rioja), 2021, pp. 135–142.
[32] M. Barceló, A. Baglietto, Hacia una economía del conocimiento, Madrid: Esic (2001).
[33] L. Bass, P. Clements, R. Kazman, Software architecture in practice, Addison-Wesley Professional, 2003.
[34] R. S. Pressman, C. Ruckaüer, L. Hernández Yáñez, et al., Ingeniería del Software: Un enfoque práctico, 1993.
[35] H. Florez, M. E. Sánchez, J. Villalobos, Embracing imperfection in enterprise architecture models., in: CEUR Workshop Proceedings, Citeseer, 2013, pp. 8–17.

[36] A. Gerber, A. Barnard, A. Van der Merwe, Design and evaluation criteria for layered architectures, 2006.

[37] V. H. M. García, P. F. Pérez, J. Rolón, Arquitectura de un sistema de gestión del conocimiento basado en agentes inteligentes, 2008.

[38] E. Woods, M. Sheina, Knowledge management: applications, markets and technologies, Ovum, 1998.

[39] G. Lawton, Knowledge management: Ready for prime time?, Computer 34 (2001) 12–14.

[40] A. Tiwana, The knowledge management toolkit, volume 5, Prentice Hall Englewood-Cliffs, 1999.

[41] L. Kerschberg, Knowledge management in heterogeneous data warehouse environments, in: International Conference on Data Warehousing and Knowledge Discovery, Springer, 2001, pp. 1–10.

[42] E. P. Zavala Zavala, Propuesta de software de gestión del conocimiento para la optimización de la orientación al contribuyente, SUNEDU (2019).

[43] N. Jofré Pasinetti, G. Rodríguez, Y. Alvarado, J. Fernandez, R. A. Guerrero, Plataforma para repositorios digitales 3d de colecciones biológicas, 2019.

[44] O. Moscoso-Zea, J. Castro, J. Paredes-Gualtor, S. Luján-Mora, A hybrid infrastructure of enterprise architecture and business intelligence & analytics for knowledge management in education, IEEE Access 7 (2019) 38778–38788.

[45] P. Gómez, M. Sánchez, H. Florez, J. Villalobos, An approach to the co-creation of models and metamodels in enterprise architecture projects, Journal of Object Technology 13 (2014) 1–29.

[46] D. Sanchez, O. Mendez, H. Florez, Applying the 3-layer model in the construction of a framework to create web applications, 2017.

[47] V. De Freitas, G. Y. Oltra, Una propuesta de arquitectura para los sistemas informáticos de gestión del conocimiento en instituciones de educación superior, Revista ESPACIOS| Vol. 36 (N° 10) Año 2015 (2015).

[48] W. Jin-Feng, C. Ming-Yan, F. Li-Jie, Y. Jun-Ju, The construction of enterprise tacit knowledge sharing stimulation system oriented to employee individual, Procedia engineering 174 (2017) 289–300.

[49] D. Paschek, L. Ivascu, A. Draghici, Knowledge management–the foundation for a successful business process management, Procedia-Social and Behavioral Sciences 238 (2018) 182–191.

[50] F. M. Córdova, F. A. Gutiérrez, Knowledge management system in service companies, Procedia computer science 139 (2018) 392–400.

[51] P. K. Wamuyu, J. R. Ndiege, Conceptualization of a knowledge management framework for governments: A case of devolved county governments in kenya, in: 2018 Thirteenth International Conference on Digital Information Management (ICDIM), IEEE, 2018, pp. 266–273.

[52] V. Roblek, M. Meško, Smart city knowledge management: Holistic review and the analysis of the urban knowledge management, in: The 21st Annual International Conference on Digital Government Research, 2020, pp. 52–60.

[53] J. J. A. Bongku, Y. Kurniawan, Designing the knowledge management system: A case study approach in it consultant company, in: Proceedings of the 2019 3rd International Conference on Graphics and Signal Processing, 2019, pp. 48–52.

[54] M. Alenezi, H. A. Basit, F. I. Khan, M. A. Beg, A comparison study of available sofware security ontologies, in: Proceedings of the Evaluation and Assessment in Software Engineering, 2020, pp. 499–504.

[55] J. Liu, Research on knowledge management technology of aerospace engineering based on big data, in: Proceedings of the 2019 3rd High Performance Computing and Cluster Technologies Conference, 2019, pp. 172–176.

[56] F.-Z. Hibbi, O. Abdoun, E. K. Haimoudi, Knowledge management in the expert model of the smart tutoring system, in: Proceedings of the 3rd International Conference on Networking, Information Systems & Security, 2020, pp. 1–4.

[57] S.-M. Tseng, W.-C. Ho, Y.-T. Jhou, The impact of social media use and knowledge management capability on supply chain agility, in: Proceedings of the 2020 the 3rd International Conference on Computers in Management and Business, 2020, pp. 296–300.

[58] S. Ismail, S. H. S. Ali, Social presence in digital community, in: 2018 International Symposium on Agent, Multi-Agent Systems and Robotics (ISAMSR), IEEE, 2018, pp. 1–5.

[59] O. Ferchichi, R. Beltaifa, L. L. Jilani, An ontological rule-based approach for software product lines evolution, in: 2020 International Multi-Conference on:"Organization of Knowledge and Advanced Technologies"(OCTA), IEEE, 2020, pp. 1–9.

[60] R. Cerchione, E. Esposito, Using knowledge management systems: A taxonomy of sme strategies, International Journal of Information Management 37 (2017) 1551–1562.

[61] T. Xiaohua, Research on higher education human resource department's knowledge management of teachers in the era of big data, in: 2020 International Conference on Big Data and Informatization Education (ICBDIE), IEEE, 2020, pp. 83–86.

[62] H. Florez, M. Sánchez, J. Villalobos, iarchimate: a tool for managing imperfection in enterprise models, in: 2014 IEEE 18th international enterprise distributed object computing conference workshops and demonstrations, IEEE, 2014, pp. 201–210.

[63] M. M. Zekeng Ndadji, M. Tchoupé Tchendji, C. Tayou Djamegni, D. Parigot, A language and methodology based on scenarios, grammars and views, for administrative business processes modelling, ParadigmPlus 1 (2020) 1–22.

[64] H. Florez, M. Sanchez, J. Villalobos, Extensible model-based approach for supporting automatic enterprise analysis, in: 2014 IEEE 18th international enterprise distributed object computing conference, IEEE, 2014, pp. 32–41.

[65] A. Velasco, J. Aponte, Automated fine grained traceability links recovery between high level requirements and source code implementations, ParadigmPlus 1 (2020) 18–41.