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ORIGINAL

Aspects of enterprise architecture in emerging technologies, smart cities and the health sector: a bibliometric study

Aspectos de la arquitectura empresarial en tecnologías emergentes, ciudades inteligentes y el sector salud: un estudio bibliométrico

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ABSTRACT

The article conducts a bibliometric study to identify application factors and trends in the implementation of enterprise architecture (EA) in emerging technologies, in health and smart cities. The benefits of using enterprise architecture in various contexts are discussed, such as the complexity of its implementation in healthcare, including the need to balance institutional logics, ensuring privacy and security of patient data to improve operational efficiency and patient care. Additionally, the potential of EA to address the complexity and integration of systems associated with digital transformation in smart cities is highlighted, linking emerging technologies such as the Internet of Things, Cloud Computing, Big Data and Artificial Intelligence.

Keywords: Enterprise Architecture; Big Data; Internet of Things; Smart Cities; Cloud Computing.

RESUMEN

El artículo hace un estudio bibliométrico para identificar factores de aplicaciones, tendencias en la implementación de la arquitectura empresarial (AE) en tecnologías emergentes, en el área de la salud y ciudades inteligentes. Se discuten los beneficios del uso de la arquitectura empresarial en varios contextos, como por ejemplo la complejidad de su implementación en la atención médica, incluyendo la necesidad de equilibrar las lógicas institucionales, garantizando la privacidad, seguridad de los datos de los pacientes para mejorar la eficiencia operativa y la atención de los mismos. Adicional se destaca el potencial de la AE para abordar la complejidad y la integración de sistemas asociada a la transformación digital en las ciudades inteligentes vinculando las tecnologías emergentes como Internet de las cosas, Computación en la nube, Big Data e inteligencia artificial.

Palabras clave: Arquitectura Empresarial; Grandes Datos; Internet de las Cosas; Ciudades Inteligentes; Computación en la Nube.

INTRODUCTION

Enterprise Architecture (EA) excels at managing an organization's IT resources in a structured way, providing a framework for aligning business objectives with information technology (IT) strategies. In the healthcare technology sector, it acts as a critical bridge between strategy and execution, enabling healthcare organizations to not only plan their technology resources but also implement them in a way that directly supports clinical

and administrative objectives. EA provides a detailed blueprint that guides the integration and alignment of information technologies with business processes and end users' needs, including medical staff and patients.[1]

This paper aims to provide an overview of the current state of research in the field of EC, highlighting the challenges and benefits of its application in different settings. The findings show that EC is important in the health sector because it favors the integration and alignment of information systems, processes, and people in administration and medical care, facilitating collaboration, interoperability, and efficiency in the delivery of services. In healthcare, EC improves operational efficiency and patient care by aligning technology with business strategy, ensuring the privacy and security of patient data.[2] EA also excels in change management within healthcare organizations, as healthcare technologies constantly evolve. It enables agile adaptation to new regulations and emerging technologies such as artificial intelligence and telemedicine, including changes in patient expectations.

The impact of EC in cities achieves cross-sectoral and cross-functional integration, improving the operational efficiency of the administration by integrating various departments and private and public actors. In addition, it addresses concerns and challenges related to privacy, quality, governance, intellectual property, and data security, facilitating the integration of health services with other municipal services and contributing to the creation of an urban ecosystem that promotes overall well-being. This includes emergency management, public health crisis response, and the promotion of healthy environments through data-informed urban planning.[3]

The research work is presented as follows: in the next chapter, the working methodology is presented. Then, in chapter three, the development of the bibliometric study is shown. This is followed by the results in chapter four; in chapter five, based on the results, the discussion is presented. Finally, in chapters six and seven, the conclusions and bibliography are used.

METHOD

The bibliometric study uses Kitchenham's(4) protocol for reviewing the state of the art, allowing the evaluation and analysis of the results to answer the research questions and thus support the researchers. There are three phases, namely:

- Planning: These are preliminary activities for the review, which include the definition of the research questions, the criteria for the inclusion and exclusion of studies, the sources of information, the search strategy, and the procedures for categorization.
- Execution consists of searching for and selecting studies to extract and synthesize the data obtained from them.
- Results: this is the final stage, focused on writing up the results according to the established research questions. The results of the review provide a critical analysis by the authors.

RESULTS

Planning

Formulation of research questions and purpose: table 1 presents the questions to be answered with the research and the justification for their posing:

Table 1. Categories of research

No.	Research question	Purpose of the question
PI1	When and where was the study published?	The aim of the question is to identify and understand the sources of specific publications related to the subject matter, as well as the dates on which they were published.
PI2	What research trends are linked to EC and smart technologies?	It is important to know the state of the art and challenges of smart technologies with AE applications as AE helps organisations to overcome these challenges by providing large-scale planning and understanding of the interdependencies between various IT components.[5]
PI3	What research trends are related to EC in the health sector?	EA is important in the healthcare sector because it helps align IT WITH business strategy, and many organisations are making considerable efforts to implement it. Innovative use of IT in the healthcare sector will have a significant impact on logistics and patient care.[6]
PI4	What is the impact of EC on urban infrastructure planning and management in the context of smart technologies?	Through the use of EC, cities achieve cross-sectoral and multifunctional integration. This brings together multiple civic and public services provided by multiple agencies, which is the most important element of city EA. In addition, EC improves the operational efficiency of the administration by integrating various private and public departments and actors.[7]

The following inclusion and exclusion criteria are applied in selecting articles: one inclusion criterion (IC) and four exclusion criteria (EC). The inclusion criteria are: (IC1) Journal articles with studies on EC and emerging technologies; EC applied to the health sector; and EC applied to technological development and improved citizens' quality of life. The guidelines to establish the exclusion criteria: (CE1) It cannot be an article older than 10 years of publication. (CE2): The article's publication language must not be different from English or Spanish. (CE3) Publications related to the same topic, the oldest one, are excluded—(CE4) Articles with unrelated studies.

This research aimed to identify articles related to EC applied in the health sector, emerging technologies, or innovative technologies such as artificial intelligence, cloud computing, data, Internet of Things, or Blockchain technologies. To achieve the above, keywords in all journals were used to build the specific search string, such as: 'Enterprise + Architecture + in + Health,' 'Enterprise + Architecture + in + Hospitals', 'Enterprise + Architecture + in + Artificial + Intelligent,' 'Enterprise + Architecture + in + Bigdata,' 'Enterprise + Architecture + in + Internet + of + Thing,' 'Enterprise + Architecture + in + smart Technologies' and 'Enterprise + Architecture + in + Blockchain.' Using the search criteria, queries were made in the following databases: Scopus, Web of Science, IEEE, Google Scholar, and Science Direct...

Execution

A search was carried out in the mentioned databases, collecting around 250 articles related to the search objective. Once the duplicated publications were eliminated, taking into account the established inclusion and exclusion criteria, 33 relevant publications were obtained, 19 from Web of Science, 13 from Scopus, and one from Google Scholar: to structure the model, the CRISP-DM methodology was taken as a reference, structuring the model in five phases that allow a comprehensive understanding of the process analysis applied to the academic program based on the study plan.

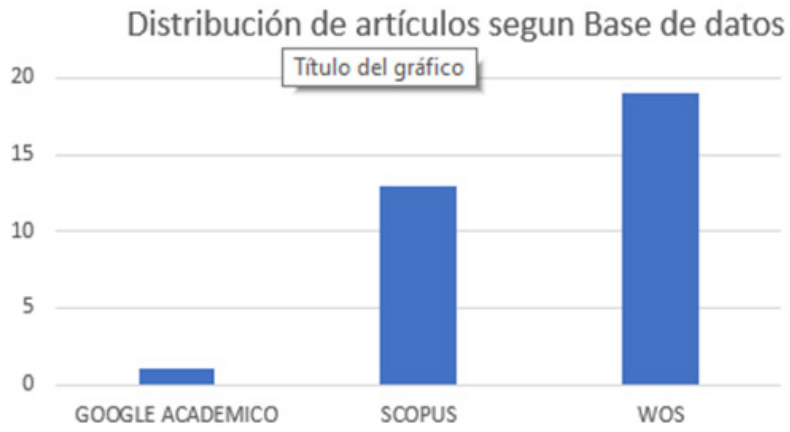

Figure 1. Distribution of articles according to database

The 33 articles obtained are detailed below:

Table 2. Results of selected articles

No	Article	Contribution	Limitations	BD
1	Developing a government enterprise architecture framework to support the requirements of big and open linked data with the use of cloud computing.[8]	They propose the Government Enterprise Architecture Framework (GEFA) designed to support the storage, processing and publication of linked big and open data using cloud computing.	It is not open in application to other countries, because of the use of the methodology developed mainly in the Czech public sector, together with the availability of related materials only in the Czech language.	WOS
2	Hospital enterprise architecture framework (study of Iranian University Hospital Organization).[9]	They suggest a model for the Hospital Enterprise Architecture Framework tailored to the specific needs of Iranian hospitals.	It is based on an exploratory and empirical study conducted in a specific Portuguese hospital. This limits the generalisability of the results to other hospital settings or countries.	WOS

3	Roles and capabilities of enterprise architecture in Big data analytics technology adoption and implementation. [5]	Identifies the challenges in adopting and implementing Big Data Analytics (BDA) in organisations, as well as exploring the dynamic roles and capabilities of Enterprise Architecture (EA) in this process.	It is mentioned that the effectiveness of EC appears to be limited in the initial stages of BDA implementation, suggesting that more research is needed to better understand how to use EC more effectively in this process.	WOS
4	Extending enterprise architectures for Adopting the Internet of Things – Lessons learned from the smartPORT projects in Hamburg.[10]	Development of enterprise architecture models that address the challenges and changes that arise when adopting IoT technologies.	Shortage of information available in literature and in practice on how companies should adapt their EA models when integrating IoT systems	SCOPUS
5	Toward an information systems architecture model for university hospitals: a case study in a Brazilian public hospital.[11]	To present a model for the construction of information systems architecture in university hospitals, as well as a practical contribution by providing a holistic view of ICT in the hospital, identifying recurrent problems and proposing possible solutions.	The proposed model does not address all the specific needs of each university hospital, as organisations have unique contexts and requirements that are not fully covered by the developed model.	WOS
6	Designing enterprise architecture systems information on cloud computing based TOGAF ADM clinic (Case study in healthy family clinic in Kampar District).[2]	The implementation of a cloud-based enterprise architecture system using the TOGAF ADM method. It focuses on improving the quality of services provided by the clinic by optimising its internal processes and managing information more efficiently and effectively.	It focuses on a specific case and does not provide a comparative assessment with other clinics or health systems. This limits the generalisability of the results and the applicability of the findings to a wider health sector context.	SCOPUS
7	Enterprise architecture institutionalization for health information exchange (HIE) cloud migration.[12]	It proposes an enterprise architecture that supports the migration of a Health Information System to the cloud to facilitate the timely exchange of health data. In addition, an EA institutionalisation framework is presented that highlights the strategies and artefacts needed to leverage the proposed architecture.	There is no guarantee that the transition to a cloud-based solution will be smooth and beneficial for all parties involved in the exchange of health information.	SCOPUS
8	A survey on the application of enterprise architecture in healthcare systems: challenges, positive impacts, and success factors.[13]	Provides a detailed understanding of the current state of implementation of EC in Health Systems. Based on systematic literature reviews, it identifies the contexts, challenges, positive impacts and critical success factors related to the implementation of EC in healthcare settings.	Lack of consensus on critical success factors for EC implementation in health systems. Despite analysing 46 studies, only two mentioned eight critical success factors, suggesting that there is a gap in the understanding of the key elements for success in this specific context.	WOS
9	Augmenting mobile cloud computing through enterprise architecture: A survey paper. [14]	It presents a framework that enables the partial transfer of computing from resource-constrained devices to resource-rich computing infrastructures, known as 'CloneCloud'. This innovative idea seeks to improve the performance of applications on resource-constrained devices by replicating the smartphone image in a powerful virtual machine.	Although interesting conceptual frameworks and solutions are presented, the research does not delve into the practical implementation of these systems in real environments. Furthermore, it is mentioned that some security modules are still in progress, suggesting that the full implementation of the proposed solutions is not fully developed at the time of the research.	SCOPUS
10	Extending enterprise architecture modeling languages for domain specificity and collaboration: application to telecommunications service design.[15]	It focuses on the coherent synthesis of various topics related to collaborative methods for enterprise modelling, design justification capture and model-driven engineering. The research addresses the need to extend enterprise architecture modelling languages to achieve domain specificity and effective collaboration by integrating design justification capture into a domain-specific modelling language.	The research does not fully resolve the question of how the design rationale of a previous architectural style should or could remain available in a new one. This question of the evolution of the design rationale remains an open issue in the proposal presented.	WOS

11	Employing enterprise architecture for applications assurance.[16]	It stresses the importance of using formal methods in application specification, the use of secure design patterns, secure session management, and the integration of security controls in the software architecture.	While general concepts and practices for improving software security through enterprise architecture are discussed, no specific case studies or examples of how these strategies are applied in real-world environments are provided.	SCOPUS
12	Development of an enterprise architecture for healthcare using TOGAF ADM.[17]	A Governance Architecture scheme was developed that optimises existing units, expands roles, divides functions and reorganises the interaction between existing units to improve the governance process at the Cancer Hospital in Dharmais, Jakarta Indonesia.	Gaps were identified and recommendations were generated to address them, no specific information is provided on how these improvements will be implemented in practice.	SCOPUS
13	Driving digital transformation of comprehensive primary health services at scale in India: an enterprise architecture framework.[18]	They propose a federated enterprise architecture or platform approach to primary health care services in India. This approach seeks standardisation and security, while offering interoperability and customisation.	Lack of scalability, limited configurability and weak security and privacy frameworks currently limit the potential of technology to advance comprehensive primary health care in India.	WOS
14	Enterprise application architecture development based on DoDAF and TOGAF.[19]	Proposal for an adapted enterprise application architecture description framework integrating DoDAF and TOGAF principles.	The proposed framework and roadmap for enterprise architecture development are based on specific case studies and are not universally applicable to all organisations.	WOS
15	Enterprise architecture planning information system based on cloud computing using TOGAF (Case study: Pandi .Id registry).[20]	Development of an EC information system planning model using the TOGAF ADM framework. This approach enables the design of an effective enterprise architecture that integrates developed applications with various systems and processes, resulting in a significant improvement in operational efficiency and quality of service.	The research does not cover all stages of the enterprise architecture lifecycle, which limits the depth and breadth of the proposed solutions.	SCOPUS
16	Designing interoperable health information systems using enterprise architecture approach in resource-limited countries: a literature review.[21]	It highlights how EC integrates business and technical processes to improve the interoperability of health information systems, thereby addressing the specific needs of these resource-constrained environments.	The lack of systematic outcome evaluations of EC-based systems to determine their long-term effectiveness.	WOS
17	Analysis and implementation of the impact of change: application to heterogeneity algorithms in enterprise architecture.[22]	Proposal of models and metrics to assess and analyse the complexity of the enterprise architecture, with a special focus on the heterogeneity of components and relationships. Development of a model to automatically detect the change of metrics and their impact on the enterprise architecture.	Lack of extensive empirical validation of the proposed models and measures developed to assess the complexity of EC, the heterogeneity of its components and relationships.	SCOPUS
18	Enterprise architecture operationalization and institutional pluralism: the case of the Norwegian hospital sector.[23]	It develops a descriptive model that shows how the logic of EC interacts with other pre-existing logics, creating tensions during project deliberations. This model provides a deeper understanding of how multiple institutional logics influence decision-making in EC projects.	It was carried out in a specific context in Norway, which is characterised by a work culture with low power distance and democratic processes. This influences the findings and the management of tensions through paradoxical approaches that allow different logics to persist. Generalisability of the results to other cultural contexts is therefore limited.	WOS
19	Application of cyclomatic complexity in enterprise architecture frameworks.[24]	roposal of an approach to estimate enterprise architecture complexity using cyclomatic complexity. This approach is based on the use of conventional enterprise architecture artefacts and relatively simple calculations to compute the cyclomatic complexity estimate.	There is no comprehensive empirical validation of this approach in real business environments.	WOS

20	Factores relevantes para inicio de arquitecturas empresariales en el sector público colombiano. Estudio bibliométrico.[25]	It analyses in detail the critical factors such as top management commitment, information systems governance, resource allocation, responsibility allocation and organisational culture that influence the successful implementation of EA in the government context.	Lack of specific data or detailed case studies illustrating the practical application of the identified factors in Colombian public entities.	GOOGLE ACADEMICO
21	Gestión de tecnología de información para gobiernos inteligentes: un enfoque de arquitectura empresarial.[26]	The research highlights how IT EAs are fundamental to the development of smart governments and how their implementation positively impacts the modernisation and efficiency of public administration, as well as the interaction between government and citizens.	The lack of a clear and agreed definition of Smart Government limits the depth of analysis and practical application of enterprise architectures in this context.	SCOPUS
22	Enterprise architecture management as a solution for addressing general data protection regulation requirements in a big data context: A systematic mapping study.[27]	The research highlights the importance of Enterprise Architecture Management (EAM) in providing guidance to ensure the security and protection of personal data in a Big Data environment, especially in the context of the demands and challenges imposed by the General Data Protection Regulation.	It identifies a lack of comprehensive exploration of how GAE practices specifically contribute to risk management and data governance in Big Data environments.	WOS
23	Digital and smart services - The application of enterprise architecture.[28]	It focuses on the alignment and connection related to the service layer in the Architectural Framework, providing guidance to address the complexity of heterogeneous systems and technologies in smart urban environments.	Many of the existing approaches to EA developed for Smart Cities are mainly derived from experience in the corporate and profit-oriented sector, with limited consideration of the specificities of the public sector.	SCOPUS
24	Cities as enterprises: a comparison of smart city frameworks based on enterprise architecture requirements.[3]	Identification of the essential requirements for enterprise architecture in smart cities, as well as the review and comparison of existing smart city frameworks against these requirements.	Most of the reviewed smart city frameworks focus on the data, application and technology layers, rather than focusing on the business layer that includes city goals, objectives and indicators.	SCOPUS
25	Enterprise architecture as a responsible data driven urban digitization framework: enabling circular cities in India.[7]	The proposal of an enterprise architecture framework for digital cities that integrates emerging technologies in a responsible manner, promoting operational efficiency in government and facilitating the delivery of urban public services in an integrated and effective way.	Limited availability and homogeneity of subject matter experts affects the generalisability of the results. In addition, the research lacks prior secondary information on certain topics, such as the application of Blockchain and cybersecurity in the context of Indian cities.	SCOPUS
26	Standardisation of enterprise architecture development for smart cities.[29]	Development of a reference architecture for smart cities that acts as a bridge between the essential requirements of the smart city context and the services needed to meet those requirements.	Some of the well-known EA frameworks have not considered critical aspects for smart cities. For example, the maintenance phase has been neglected in most existing frameworks, despite being crucial for delivering qualified and sustainable services to citizens in the context of smart cities.	SCOPUS
27	Enterprise architecture breakthrough for telecommunications transformation: a reconciliation model to solve bankruptcy.[30]	It presents the implementation of a corporate breakthrough strategy with detailed guidance, providing a new strategic approach that is easy to analyse and implement through the Enterprise Architecture (EA) approach.	Each type of industry has different characteristics resulting in different contributions to the proposed strategic model, which highlights the need to further analyse other IoT-based industries according to the approach proposed in the research.	WOS
28	Modelling pervasive platforms and digital services for smart urban transformation using an enterprise architecture framework.[31]	Presentation of an Enterprise Architecture Framework that provides a structure for managing change and sustaining urban transformation.	It relied solely on semi-structured interviews to validate the integration of digital platform services, without fully addressing other identified dimensions of IT systems and infrastructure capacity in the study.	WOS

29	A model to evaluate the acceptance and usefulness of enterprise architecture for digitalization of cities.[32]	The study identifies that quality of EA service is the most significant factor influencing the intention of IT professionals and urban stakeholders to use EA in the digitisation of cities.	The study was based on data from only 18 organisations, which resulted in a limited sample size and lower statistical power affecting the reduced significance values.	WOS
30	Concepts for Modeling Smart Cities An ArchiMate Extension.[33]	It is the formulation of design principles and features for the creation of specific modelling methods for Smart Cities using ArchiMate. These principles and features provide clear guidelines on how to approach the conceptual modelling of urban services and underlying information systems in Smart Cities contexts.	It is a single case study on the city of Netanya (Israel) and its waste management service. But it provides empirical richness and a holistic view of the problem studied, the generalisability of the findings beyond this specific service and geographical scope is limited.	WOS
31	Managing digital transformation of smart cities through enterprise architecture – A review and research agenda.[34]	It is argued that enterprise architecture and digital transformation concepts are useful tools to overcome organisational barriers and foster collaboration between stakeholders in smart cities.	No real city data was used to validate the applicability of the enterprise architecture framework in the digital transformation of smart mobility in smart cities.	WOS
32	Enterprise architecture in smart cities: developing an empirical grounded research agenda.[35]	The main contribution of the research is the evaluation of the applicability of TOGAF in a real case of a Smart City, specifically in the design of a city service delivered by Limerick (Ireland).	It only mentions one specific case study in Limerick, a Smart City in Ireland. This limits the generalisability of the findings and recommendations to other smart cities with different contexts and challenges.	WOS
33	Digital transformation with enterprise architecture for smarter cities: a qualitative research approach.[36]	Development of an EA framework for aligning systems and integrating data in the digital transformation of smart cities. This EA framework is used to address the challenges of systems alignment and data integration in the context of ICT-supported smart city services.	Lack of solid empirical evidence on systems alignment and data integration in the digital transformation of cities. Despite the proposal of an EA framework to address these challenges, it is acknowledged that there is little research that has thoroughly explored the digitisation of cities from this perspective.	WOS

Results

The data analysis is carried out to answer the research questions posed.

PI1 When and where was the study published?

Counting mode: complete Counting. Minimum Occurrence: 1. Words Identified: 116. The overlay visualization is used to visualize the year of publication, as shown in figure 2.

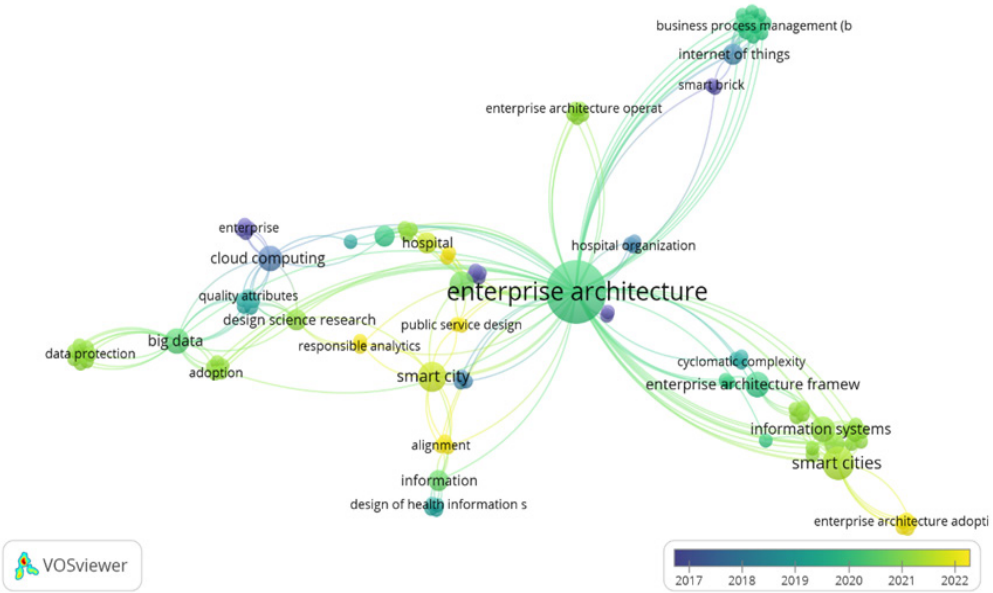

Figure 2. Number of articles by year of publication

The publications are classified using the established evaluation criteria: The analysis of key terms is carried out using the VOSViewer bibliometric network software from the list of 33 articles. In elaborating the map based on the bibliographic data maps, the following step-by-step process was carried out: Selecting the Mapping Approach by bibliographic data, the following results were obtained, expressed in input parameters and their graphical representation. Type of analysis: co-occurrence. Unit of analysis: keywords.

Year of publication: figure 2 shows that over the last four years, with approximately 60 %[SC1] (20 out of 33) of the publications in this period, the topic in question has started to grow since 2019 and has maintained its growth.

Place of publication of articles: the country that stood out most in publications within the bibliometric study is Ireland, with seven publications related to EA applied to smart cities, followed by Indonesia, with four publications on EA applied to the health sector and cloud computing. Norway is another European country that stands out regarding EC research in smart cities and the health sector. Germany and France are present with research related to EC applications in the Internet of Things and cloud computing, respectively. Powerhouses like the United States, China, and India stand out with articles on EC applied to cloud computing, smart cities, and the health sector. In Latin America, Brazil, with EC applications in the health sector, and Colombia, with EC applications in the government sector, stand out as countries that have conducted related research.

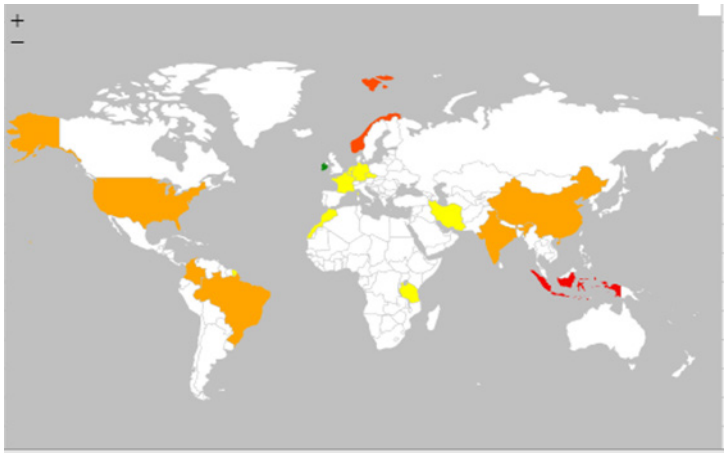

Figure 3. Number of articles published by country

PI2 What research trends are linked to EC and smart technologies?

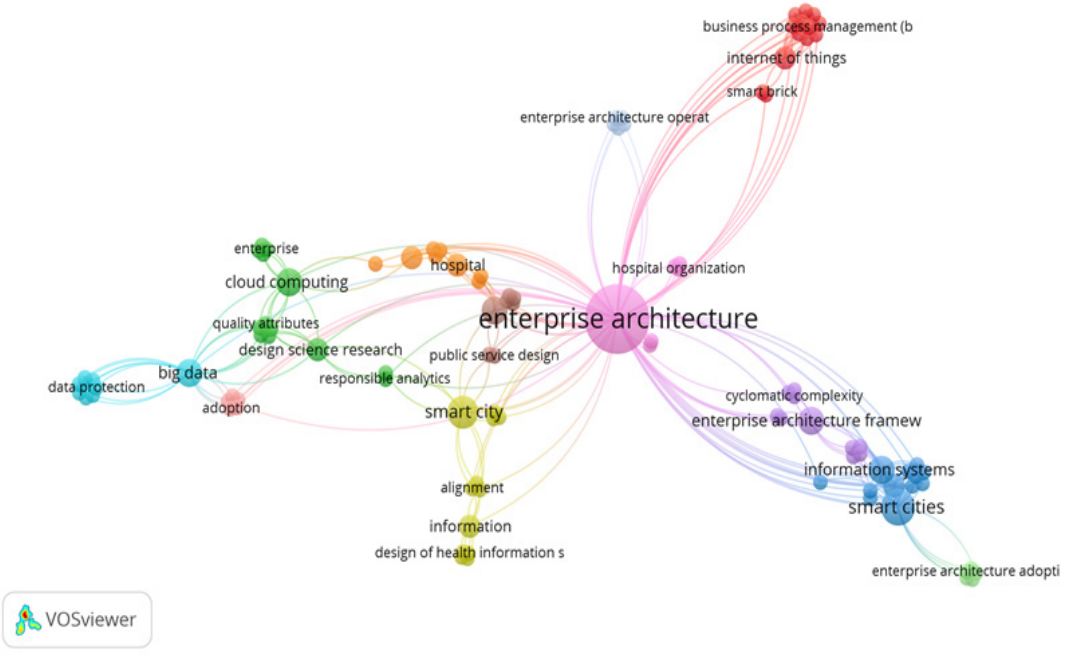

Figure 4. Keyword map

Research classifies EA applications into three broad groups, namely: AE with Big Data, AE with IOT and AE with Cloud Computing.

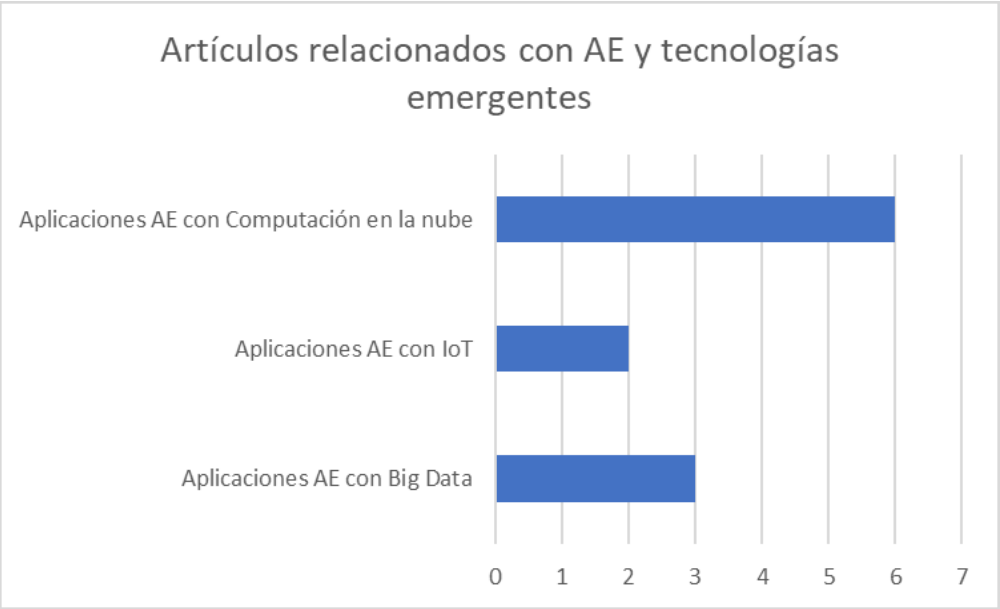

Figure 5. Number of articles related to EC and emerging technologies

Emerging technologies contributing to IT transformation and enabling its integration include the Internet of Things, Cloud Computing, Big Data, and Artificial Intelligence.[37] Together with support for open data policies, these technologies are creating the conditions for a new period of intense societal transformation.

Research related to EA with Big Data stands out for its study of and applications of EA in the handling of large volumes of data in the private sector and public sector organizations. The research states that the management of EC and big data must comply with data protection regulations.

In EA applications with IoT, the authors developed an EA model for the Internet of Things (IoT) as an essential element for effectively implementing IoT systems in an organization, applying a case study of the Hamburg Port Authority (HPA). Another study by the authors incorporates IoT and AE technologies to solve problems in Indonesia's real estate industry. The paper suggests using a mobile application that connects buyers and sellers to improve the real estate business system.

In AE Applications with Cloud Computing, they mention mobile cloud computing through AE. The authors create an enterprise application architecture description framework using the TOGAF ADM approach and cloud computing technology, providing a comprehensive approach to enterprise application architecture with applications in various contexts.

The authors mention that many modern telecommunication services and enterprise applications are deployed in the cloud. Integrating a domain-specific modeling language (DSML) and stakeholder collaboration facilitates the design and management of cloud-based architectures.

The study suggests that software engineers improve the security and reliability of their applications by following the practical recommendations outlined in its EA. Cloud security also requires special attention to architecture and design to mitigate specific risks associated with cloud infrastructure and services.

In their research, they propose models and measures to assess and analyze the complexity of EC, specifically the heterogeneity of components and relationships, in implementing EC that are being adopted for cloud solutions.[38]

PI3 What research trends are related to EC in the health sector?

To achieve an adequate articulation between technology and organizational strategy, EC becomes the most propitious alternative to strengthen the business mission and improve the portfolio of services provided by health organizations such as hospitals, clinics, and others.[39]

The authors propose designing an EC system for a healthy family clinic in Indonesia and an Iranian hospital using the TOGAF ADM framework and cloud computing technology.

The study presents a case study of designing an information systems architecture model for a Brazilian public hospital. It highlights the importance of EC in supporting IT management and governance in organizations. The study also identifies gaps, challenges, and viable solutions for decision-making to improve service delivery and IT alignment with other areas of the hospital.

The EC framework proposed helps health information exchanges migrate to a cloud architecture by providing a validation framework to test the implementation of this migration.

The authors conclude that EC is a valuable resource for healthcare organizations to improve their IT infrastructure, applications, and data management, resulting in good patient outcomes and organizational performance.

With their research, the authors state that the TOGAF ADM framework helps healthcare organizations, such as Dharmais Cancer Hospital in Jakarta, Indonesia, improve their IT infrastructure and align it with their business strategy.

The authors argue that adopting an EC framework is essential for successfully implementing digital health solutions in primary care in India.

The research highlights the importance of EC in healthcare because it provides a holistic approach to designing and implementing health information systems that are interoperable, scalable, and sustainable.

The research identifies the tensions between existing medical, technical, and management concepts and EC principles and assumptions.

The article proposes a new method for estimating the complexity of enterprises using cyclomatic complexity in EC frameworks. The authors argue that complexity measurement is essential for successful systems engineering and development planning. The proposed method provides a tool for enterprise architects to assess the complexity of enterprises of their interest easily.

PI4 What is the impact of EC on the planning and management of urban infrastructure in the context of innovative technologies?

Through the use of EC, cities achieve cross-sectoral and cross-functional integration, helping to improve the operational efficiency of the administration by integrating various departments and private and public actors. This brings together multiple civic and public services provided by different agencies, which is the most crucial element of city EA (7). The following selected articles apply EC with emerging technologies in implementing innovative city projects.

The study identifies the factors that need to be considered for a successful implementation of AE in the public sector, including social aspects such as organizational culture, communication, and stakeholder management; administrative aspects such as governance, budget, and risk management; and technical aspects such as interoperability and transformation.

The authors identify that AE enables the integration and alignment of information systems, processes, and people in public administration, which facilitates collaboration, interoperability, and efficiency in service delivery.

The research states that AE provides a way to connect the different architectural components, resulting in a coherent and integrated architecture to guide the design of smart city services.

The authors state that EA aligns strategy with the impact on citizens' quality of life, supports their development and transformation based on the city's strategic plan, and helps ensure that smart city services are effective, efficient, sustainable, and deliver real value to citizens.

The research highlights that, through the use of EA, cities achieve cross-sectoral and cross-functional integration into a single horizontally integrated EA, bringing together multiple civic and public services provided by multiple agencies.

The authors argue that EC in smart cities provides a framework for managing the complexity of IT services. Smart cities are complex systems that use IT services to improve citizens' quality of life, and managing these services is challenging due to the multi-stakeholder nature of smart cities. EA frameworks help to address these challenges by providing a standardized approach to developing innovative services and managing EAs in smart cities. By setting contextual requirements and definitions for innovative city systems and services, EA frameworks contribute to our understanding of smart city enterprise architectures and help improve the quality of services provided to citizens.

In the research, they state that the integration between EC, Communication Service Providers (CSPs), and smart city involves the use of EC as a framework to align the business processes and IT infrastructure of CSPs with the needs of the smart city, which is usually organized by the local government or city administrative authorities. The paper uses the case of the SmartSantander project in Northern Spain, where the city council organizes the project. The project has eight main use cases, which are supported and managed by providers supervised by the city council. All use cases are integrated under the leadership of the city council and the smart city solutions integrator. CSPs collaborate with the 'smart city' industry as a utility industry, supplying wireless Internet for all IoT devices and contributing to the development of smart devices. The paper proposes that CSP use the ArchiMate language in the AE model to provide a common language and ensure that all stakeholders understand the CSP's business processes and IT infrastructure.

The authors present a developed enterprise architecture framework (EFA) that assists municipalities

with a bottom-up decision support model to improve communication and collaboration between municipal administration, researchers, and practitioners interested in city digital transformation.

In the study, they developed a theoretical model based on DeLone and McLean's IS success model and validated it through survey data collected from 18 organizations in Norway and Ireland. The study examines the factors that influence the acceptance and use of EC for digitizing cities, including system quality, information quality, and service quality.

The authors propose an extension of ArchiMate to model smart cities, focusing on city services and their underlying IS that are aligned with city goals and objectives.

The study analyses the importance of EA and digital transformation in the development of smart cities.

In the research, the authors conducted a case study on the application of TOGAF in the design of a pedestrian counter service in the city of Limerick, Ireland, and found that TOGAF provides a structured approach to designing and managing complex smart city systems.

This paper presents an e-mobility case study demonstrating the use of EA to achieve systems alignment and data integration in digital transformation.

DISCUSSION

The importance of integrating emerging technologies such as the Internet of Things, Cloud Computing, and Big Data in Enterprise Architecture applied to smart cities and health services is highlighted. This integration improves data management, operational efficiency, and strategic decision-making in complex environments. The research addresses the intersection between EC, innovative technologies, the health sector, and urbanism, representing an interdisciplinary approach that seeks to generate creative and sustainable solutions to improve people's quality of life and the efficiency of public services.

Among the benefits identified in the implementation of EC in emerging technologies, smart cities, and the health sector is to provide a complete and informative vision for the management of large volumes of data in different sectors, including public and health, as in the case of Big Data and cloud computing to improve information management. IoT, meanwhile, facilitates the interconnection of devices and systems in complex environments such as healthcare, enabling greater coordination and efficiency in the delivery of healthcare services. In smart cities, it improves the connectivity and interoperability of information systems, optimizing the management of urban resources. Cloud computing allows organizations to align their business objectives with IT strategies, offering more efficient services to customers and organizations. It facilitates mobility and customer satisfaction through IT services, which are critical in business and healthcare environments.

One of the main challenges is the effective integration of emerging technologies such as Big Data, IoT, and Cloud Computing in EC, which is the optimization of data and process management in healthcare environments, including smart cities.

Future research could focus on exploring new technologies and innovative approaches to improve enterprise architecture integration with smart technologies in urban and healthcare environments and optimize operational efficiency and quality of services. Comparative studies and case studies that assess the effectiveness of EC in implementing technology solutions in different contexts are suggested, which could provide valuable inputs for decision-making and continuous improvement. It could also focus on evaluating the social, economic, and environmental impact of the application of EC in urban and health environments, considering aspects such as sustainability, equity in access to services, and improving citizens' quality of life.

CONCLUSIONS

The research presented in the article differs from other literature reviews in that it focuses on Emerging Technologies in the framework of EC applied to specific sectors such as health and smart cities. This combination of disciplines and interdisciplinary approaches allows for the identification of synergies and application opportunities beyond traditional reviews; this innovative and up-to-date perspective provides a cutting-edge view of how these technologies can transform the management of information systems in complex environments.

The Open Group Architecture Framework (TOGAF) stands out in the research for being mentioned in applications with emerging technologies in healthcare and smart cities.

Enterprise architecture provides a structured approach to designing and managing the complex systems and processes of delivering healthcare services. Hospitals have a high degree of specialization, a heterogeneous mix of stakeholders and interests, and very complex ICT infrastructures. Therefore, it is necessary to create tailor-made enterprise architectures that can adapt to agile changes in services, processes, and systems.

In smart cities, EA provides a framework for planning, designing, and realizing a city's sustainability goals in relation to its business processes and information systems. EA helps to create transparency by documenting the actual state of the city's systems, giving city managers control over the complexity of information systems and processes.

The bibliometric study provides a repository of relevant data to help researchers find success stories of the

application of EC in health and broaden their understanding of the phenomenon, which can be helpful for future research and the implementation of health solutions. In the case of the articles reviewed, these do not reflect applications of emerging technologies and EC in the health sector simultaneously, creating an opportunity for future research on the application of these concepts in Smart Hospitals or Smart Health, thus generating models for the adoption of technologies that facilitate the operation and management processes of these new health entities. Integrating emerging technologies, such as the Internet of Things, Cloud Computing, Big Data, and Artificial Intelligence, can benefit the application of EC in healthcare, improving data management and interoperability between IT systems.

REFERENCES

1. Yovanof GS, Hazapis GN. An architectural framework and enabling wireless technologies for digital cities & intelligent urban environments. Wirel Pers Commun. 2009; 49(3): 445–63. doi:10.1007/s11277-009-9693-4.

2. Lidyawati R, Legowo N, Wang G. Designing enterprise architecture systems information on cloud computing based TOGAF ADM clinic (Case study in healthy family clinic in Kampar district). Int J Adv Trends Comput Sci Eng. 2019; 8(6): 3043–8. doi:10.30534/ijatcse/2019/61862019.

3. Bastidas V, Bezbradica M, Helfert M. Cities as enterprises: A comparison of smart city frameworks based on enterprise architecture requirements. Lect Notes Comput Sci. 2017; 10268: 20–8. doi:10.1007/978-3-319-59513-9_3.

4. Kitchenham B. Guidelines for performing systematic literature reviews in software engineering [Internet]. 2007 [citado Año-Mes-Día]. Disponible en: https://www.researchgate.net/publication/302924724

5. Gong Y, Janssen M. Roles and capabilities of enterprise architecture in big data analytics technology adoption and implementation. J Theor Appl Electron Commer Res. 2021; 16(1): 37–51. doi:10.4067/S0718-18762021000100104.

6. Olsen DH. Enterprise architecture management challenges in the Norwegian health sector. Procedia Comput Sci. 2017; 121: 637–45. doi:10.1016/j.procs.2017.11.084.

7. Choudhuri B, Srivastava PR, Mangla SK, Kazancoglu Y. Enterprise architecture as a responsible data-driven urban digitization framework: enabling circular cities in India. Ann Oper Res. 2023. doi:10.1007/s10479-023-05187-8.

8. Lnenicka M, Komarkova J. Developing a government enterprise architecture framework to support the requirements of big and open linked data with the use of cloud computing. Int J Inf Manag. 2019; 46: 124–41. doi:10.1016/j.ijinfomgt.2018.12.003.

9. Haghighathoseini A, Bobarshad H, Saghafi F, Rezaei MS, Bagherzadeh N. Hospital enterprise architecture framework (study of Iranian university hospital organization). Int J Med Inform. 2018; 114: 88–100. doi:10.1016/j.ijmedinf.2018.03.009.

10. Schirmer I, Drews P, Saxe S, Baldauf U, Tesse J. Extending enterprise architectures for adopting the Internet of Things – Lessons learned from the smartPORT projects in Hamburg. Lect Notes Bus Inf Process. 2016; 255: 169–80. doi:10.1007/978-3-319-39426-8_14.

11. Júnior SH da L, Medeiros FPA de, Lira HB. Toward an information systems architecture model for university hospitals: A case study in a Brazilian public hospital. Electron J Inf Syst Dev Ctries. 2022. doi:10.1002/isd2.12248.

12. Osei-Tutu K, Song YT. Enterprise architecture institutionalization for Health Information Exchange (HIE) cloud migration. Adv Sci Technol Eng Syst. 2020; 5(5): 680–91. doi:10.25046/AJ050584.

13. Alencar de Medeiros FP, Júnior SH da L, Silva FÍC, Albuquerque GSG, Lira HB. A Survey on the Application of Enterprise Architecture in Healthcare Systems. Int J Enterp Inf Syst. 2021; 17(3): 1–15. doi:10.4018/ijeis.2021070101.

14. Muhammad K, Khan MNA. Augmenting mobile cloud computing through enterprise architecture: A survey paper. Int J Grid Distrib Comput. 2015; 8(3): 323–36. doi:10.14257/ijgdc.2015.8.3.30.

15. Chiprianov V, Kermarrec Y, Rouvrais S, Simonin J. Extending Enterprise Architecture Modeling Languages for Domain Specificity and Collaboration: Application to Telecommunications Service Design Extending. Softw Syst Model. 2014; 13(3). doi:10.1007/s10270.

16. Houser W. Employing enterprise architecture for applications assurance. IT Prof. 2014; 16(6): 8–11. doi:10.1109/MITP.2014.91.

17. Girsang AS, Abimanyu A. Development of an enterprise architecture for healthcare using TOGAF ADM. Emerg Sci J. 2021; 5(3): 305–21. doi:10.28991/esj-2021-01278.

18. Nadhamuni S, John O, Kulkarni M, Nanda E, Venkatraman S, Varma D, et al. Driving digital transformation of comprehensive primary health services at scale in India: An enterprise architecture framework. BMJ Glob Health. 2021; 6. doi:10.1136/bmjgh-2021-005242.

19. Tao ZG, Luo YF, Chen CX, Wang MZ, Ni F. Enterprise application architecture development based on DoDAF and TOGAF. Enterp Inf Syst. 2017; 11(5): 627–51. doi:10.1080/17517575.2015.1068374.

20. Maulana D, Kaburuan ER, Kwek D, Kaburuan ER, Legowo N. Enterprise architecture planning information system based on cloud computing using TOGAF (Case study: Pandi .Id Registry). Int J Sci Technol Res. 2019. Disponible en: www.ijstr.org

21. Higman S, Dwivedi V, Nsaghurwe A, Busiga M, Sotter Rulagirwa H, Smith D, et al. Designing interoperable health information systems using enterprise architecture approach in resource-limited countries: A literature review. Int J Health Plann Manag. 2019; 34(1): e85–e99. doi:10.1002/hpm.2634.

22. Lakhrouit J, Baïna K. Analysis and implementation of the impact of change: Application to heterogeneity algorithms in enterprise architecture. Int J Electr Comput Eng. 2020; 10(1): 377–86. doi:10.11591/ijece.v10i1.pp377-386.

23. Ajer AKS, Hustad E, Vassilakopoulou P. Enterprise architecture operationalization and institutional pluralism: The case of the Norwegian Hospital sector. Inf Syst J. 2021; 31(4): 610–45. doi:10.1111/isj.12324.

24. Stroud RO, Ertas A, Mengel S. Application of cyclomatic complexity in enterprise architecture frameworks. IEEE Syst J. 2019; 13(3): 2166–76. doi:10.1109/JSYST.2019.2897592.

25. Cruz Bueno H, Briceño Pineda W. Factores relevantes para inicio de arquitecturas empresariales en el sector público colombiano. Estudio bibliométrico. Gerenc Tecnol Inf. 2014; 13(35): 63–77.

26. Maestre G, Nieto W. Gestión de tecnología de información para gobiernos inteligentes: un enfoque de arquitectura empresarial. Espacios. 2017; 38(42): 14–23.

27. Georgiadis G, Poels G. Enterprise architecture management as a solution for addressing general data protection regulation requirements in a big data context: a systematic mapping study. Inf Syst E-Bus Manag. 2021; 19(1): 313–62. doi:10.1007/s10257-020-00500-5.

28. Helfert M, Melo VAB, Pourzolfaghar Z. Digital and smart services - The application of enterprise architecture. Commun Comput Inf Sci. 2018; 858: 277–88. doi:10.1007/978-3-030-02843-5_22.

29. Pourzolfaghar Z, Bastidas V, Helfert M. Standardisation of enterprise architecture development for smart cities. J Knowl Econ. 2020; 11(4): 1336–57. doi:10.1007/s13132-019-00601-

30. Dachyar M, Zagloel TYM, Saragih LR. Enterprise architecture breakthrough for telecommunications transformation: A reconciliation model to solve bankruptcy. Heliyon. 2020; 6(10). doi:10.1016/j.heliyon.2020.e05273.

31. Anthony Jnr B, Abbas Petersen S, Helfert M, Ahlers D, Krogstie J. Modeling pervasive platforms and digital services for smart urban transformation using an enterprise architecture framework. Inf Technol People. 2021; 34(4): 1285–312. doi:10.1108/ITP-07-2020-0511.

32. Anthony Jnr B, Petersen SA, Krogstie J. A model to evaluate the acceptance and usefulness of enterprise

architecture for digitalization of cities. Kybernetes. 2023; 52(1): 422–47. doi:10.1108/K-07-2021-0565.

33. Bastidas V, Reychav I, Ofir A, Bezbradica M, Helfert M. Concepts for Modeling Smart Cities: An ArchiMate Extension. Bus Inf Syst Eng. 2022; 64(3): 359–73. doi:10.1007/s12599-021-00724-w.

34. Anthony Jnr B. Managing digital transformation of smart cities through enterprise architecture–a review and research agenda. Enterp Inf Syst. 2021; 15(3): 299–331. doi:10.1080/17517575.2020.1812006.

35. Bastidas V, Bezbradica M, Bilauca M, Healy M, Helfert M. Enterprise Architecture in Smart Cities: Developing an Empirical Grounded Research Agenda. J Urban Technol. 2023; 30(1): 47–70. doi:10.1080/10630732.2022.2122681.

36. Anthony Jnr B, Abbas Petersen S, Helfert M, Guo H. Digital transformation with enterprise architecture for smarter cities: a qualitative research approach. Digit Policy Regul Gov. 2021; 23(4): 355–76. doi:10.1108/DPRG-04-2020-0044.

37. Ontiveros E, Vizcaíno D, López Sabater V, Fundación Telefónica. Las ciudades del futuro: inteligentes, digitales y sostenibles. Vol. 1. Ariel; 2016.

38. Wang G, Suroso JS, Sanusi D, Tanuwijaya JA, Theodora TFI. Applying internet of things framework in real estate business with enterprise architecture approach. In: Proceedings of 2022 International Conference on Information Management and Technology, ICIMTech 2022. 2022. p. 219–24. doi:10.1109/ICIMTech55957.2022.9915151.

39. Vidal FT, Guerrero JG, Sánchez DM. Enterprise architecture to improve the outsourcing of health services in the social insurance of Peru. In: Proceedings of the 2018 IEEE 38th Central America and Panama Convention, CONCAPAN 2018. 2018. doi:10.1109/CONCAPAN.2018.8596481.

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