Knowledge Management: Innovation, Technology and Ontologies

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Abstract

Knowledge is an essential resource to create value for organizations and requires adequate Knowledge Management to generate, retain, and apply it and obtain competitive advantages. Knowledge management implies considering the people who are part of the organization as a key factor, proposing organizational cultures and aspects that favor it, and applying processes and technologies. This research used a literature review of articles published in the DBLP Computer Science Bibliography in first and second-quartile journals based on the Scimago Ranking Journal to analyze the presence of Knowledge Management, which views are considered, and which aspects of technology are most relevant. The results of this research provide an overview of relevant topics about knowledge management and allow shows the relevance relationship between knowledge management and innovation, and artificial intelligence and ontologies as a fundamental part of the application of knowledge management.

Keywords

Knowledge, Knowledge Management, Innovation, Ontology, Technology.

1. Introduction

Knowledge is an essential resource to create value for organizations that includes experiences, values, and non-contextual information allowing transformation of the organizational culture and process and increasing the economic value of companies. It required adequate management to generate, retain and apply it and obtain competitive advantages. Knowledge Management is a multi-disciplinary approach that seeks structured and systematic ways and allows management the knowledge. This paper presents in section 2 the theoretical basis associated with knowledge, knowledge management, and some terms and concepts related whit its: the views and categories for KM technologies analysis. The section 3 presents the background of the research group, the objectives of this article to increase knowledge on the topic, the proposed research questions, and the method and scope of this article. The section 4 shows the search execution in 5 steps: search execution on DBLP, the Scimago Database download, match between DBLP and Scimago and paper selection by quartile distribution, paper selection by access and paper selection by topic. Section 5 presents the results associated with the research questions. Finally, the conclusions are presented in Section 6.

2. Theorical basis

This section presents the theoretical basis for this article describing the concept of Knowledge Management 2.1, its views 2.2, and the categories of analysis of knowledge management technologies 2.3.

2.1. Knowledge Management

Knowledge Management is a multi-disciplinary approach that seeks structured and systematic ways and allows management the knowledge. Perez and Urbáez [1] defines knowledge management as "a

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managerial approach or emerging discipline that seeks in a structured and systematic way to take advantage of the knowledge generated to achieve the objectives of the organization and optimize the decision-making process". Knowledge is the most important strategic resource [2] and the companies need to generate processes to manage this resource and take advantage of the experience and skills of talents and leaders in the face of environmental contingencies, or the risks and threats of the context [3, 4, 5]. Knowledge resides in people and therefore its transmission implies a voluntary act of people, understanding knowledge as a "mixture of structured experiences, values, and non-contextual information that provides a framework for evaluating new experiences and information" [6]. It should be noted that the boundary for establishing whether a job involves knowledge or just routine operational actions without putting one's knowledge into action is still under debate.

2.2. Knowledge Management Views

A system view is a representation of the system from the perspective of a specific set of related concerns, which suppresses details to provide a simplified model that has only the elements related to the viewpoint concerns [7, 8, 9] and allows a particular element to be examined from a specific scope. A knowledge management view describes the concepts, elements, and characteristics of an integrated knowledge management system. Several authors use alternative terms to refer to the views: dimensions [10, 11], factors [12], components [13], drivers [14, 15] and critical success factors [16, 17].

Straccia et al. [18] shows an analysis of the views in different papers and the following views are obtained: a) individuals or people, b) organizational aspects, c) activities and processes, d) measurement, and e) technology; the technology view included the knowledge representation topics.

2.3. Categories for Technologies on Knowledge Management

There are different technologies for knowledge management, which can be categorized as follows [19]: a) socialization techniques, b) techniques or models for knowledge explanation and representation, c) field of study, d) logical and analytical process, e) organizational practices, and f) technological tools.

Socialization techniques are those that allow the exchange of experiences and the transfer and acquisition of tacit knowledge. Socialization is a concept that arose in other disciplines (especially sociology) but was promoted in knowledge management through the SECI model designed by Nonaka and Takeuchi [20]; socialization technique includes e.g. Community of practices, Mentoring, or Expert assistance.

The techniques or models for knowledge explanation and representation included the ways and techniques to make knowledge explicit in some support or model, including those probable models, like case studies, catalogs, directories, knowledge maps, ontologies, etc. Each technique or model is likely to be supported by technological tools, but these tools are not included in this category. For Davis et al. [21] knowledge representations "are also how we express things about the world, the medium of expression and communication in which we tell the machine (and perhaps one another) about the world. This role for representations is inevitable so long as we need to tell the machine (or other people) about the world, and so long as we do so by creating and communicating representations". For Avramenko y Kraslawski [22] the knowledge representation "is the study of how knowledge about the world can be represented and what kinds of reasoning can be done with that knowledge".

A field of study refers to a branch of knowledge or a set of branches of knowledge with interdisciplinary action; each field can include processes, technologies, etc. Some fields of study can be considered Artificial Intelligence, Big Data, Business Intelligence (BI), Cybersecurity, and the Internet of Things (IoT).

The logical and analytical process category corresponds to data and information processing and their treatment activities. It may include technological tools but especially involves analysis and exploitation processes. Some examples of logical and analytical processes are workflow, data mining, and text mining.

Organizational practice is a category that represents a mechanism to communicate its values, norms, and goals to its employees and is instrumental in corporate education, virtual learning environment, and virtual reality and simulation [23].

Finally, the last category is technological tools: artifacts that able to be deployed in a technological infrastructure environment, including the software, part of the software, or similar. In general, these tools can be modeled as components in a sequence diagram or deploy diagram of Unified Modeling Language. The different technological tools are grouped according to the following subcategories: type of systems, repositories and storage media, bidirectional communication tools, tools for content presentation, and others.

3. Research Objectives, Method and Scope

The technology for knowledge management has been a concern for the research group in recent years [18, 19, 24]: from the preliminary identification of some technologies to the identification and proposals of architecture. It has also carried out several research related to knowledge management models, processes, and measurement.

The objective of this paper is to analyze the aspects related with knowledge management in the most recognized academic literature, both on knowledge management issues in general and on technologies for the application of knowledge management in particular.

The following research questions proposed are:

1. Does the academic literature perform specific analyses for some of the views of knowledge management or does it deal with more general issues?
2. What are the views of knowledge management present in the academic literature?
3. What general issues do the literature present?
4. What information do you provide about the technology for knowledge management?

Systematic Mapping literature on DBLP Computer Science Bibliography is carried out in this paper. Systematic Mapping Studies (also known as Scoping Studies) are designed to provide a wide overview of a research area [25] and used to structure a research area, while systematic reviews are focused on gathering and synthesizing evidence [26]; this type of study allows summarize and disseminate research findings and to identify research gaps in the existing literature [27].

The mapping was executed on DBLP; this portal aims to "cover all areas of computing (from algorithms, artificial intelligence, compilers, data mining, bioinformatics, networking, robotics, security, virtualization...)" and has more than 6 million indexed papers [28] being an online reference of the main computer science publications [29]. These correspond to Step 1 and are detailed in 4.1.

To identify the journals with the highest academic level, the journals present in Quartile 1 (Q1) and Quartile 2 (Q2) were selected using the Scimago Journal Rank, a ranking with an international scope, and whose data source based on Scopus [30] and a match between BDLP and Scimago Journal Rank is executed for identify the quartile of the publication to which corresponds each paper. These activities are step 2 (shown in 4.2) and step 3 (in 4.3).

For Q1 and Q2 papers found in the previous step, a search is carried out to obtain access considering those that have free access, are accessible through a portal or with University credentials. The results are presented as step 4 in section 4.4.

Finally, in step 5 (section 4.5) a selection of documents is presented, eliminating those that meet any of the following criteria: 1. keyword only in the bibliographic references, in index terms (or keywords) or the authors' biography; 2. non-relevant use of the term; or 3. belonging or not to the topic "knowledge management" and in compliance with the theoretical framework and the KM concept proposed in this work. The selected papers after step 5 are used to analyze the results presented in section 5.

4. Search Execution

This section presents the execution of the review and the selection of the works to be analyzed in the following section.

4.1. Step 1: Search execution on DBLP

A search on DBLP Computer Science Bibliography is executed to obtain articles associated with knowledge management with the criteria presented in Table 1. A total of 376 articles were found: 126 corresponding to 2021, 126 corresponding to 2022, and 124 corresponding to 2023.

Table 1
Search Criteria

Criterial	Value
Keyword	"knowledge management"
Publication Type	Journal Article
Years	2021,2022,2023

4.2. Step 2: Scimago Database download

The Scimago database is downloaded with 28740 sources identified with their SJR Best Quartile: 8702 belong to Q1; 7295 to Q2; 6674 to Q3 and 6069 to Q4.

4.3. Step 3: Match between DBLP and Scimago and paper selection by quartile distribution

On the Scimago database, a search is made for the quartile to which each of the journals where each of the articles obtained in DBLP were published belongs, to associate each paper with a quartile. The journal and quartile are identified for 329 papers and a database of publications is generated with the following fields: title of the publication, year, journal, and quartile. Regarding the papers found in DBLP corresponding to each year, their quartile distribution is obtained and presented in Table 2. Considering the scope of the present work, the 301 papers corresponding to Q1 and Q2 are selected.

Table 2
Articles for year and quartile distribution

Year	Q1	Q2	Q3	Q4	Not Found	Total
2021	74	21	11	1	19	126
2022	78	23	6	3	16	126
2023	84	21	6	1	12	124
Total	**236**	**65**	**23**	**5**	**47**	**376**

4.4. Step 4: Paper selection by access

For Q1 and Q2 papers found in the previous step, a search is carried out to obtain access considering those that have free access, are accessible through a portal or with University credentials. The results are presented in Table 3. A total of 121 papers were found for which access is available.

Table 3
Articles Q1 y Q2 with access and without access

Year	Q1 with access	Q2 with access	Q1 without access	Q2 without access	Total
2021	49	10	25	11	95
2022	28	12	50	11	101
2023	19	3	65	18	105
Total	**96**	**25**	**140**	**40**	**301**

4.5. Step 5: Paper selection by topic

35 five papers were found to be discarded for the first criterion (keyword only in the bibliographic references, in index terms (or keywords) or the authors' biography) and 9 for the second (non-relevant use of the term) resulting in 77 papers to be analyzed in detail in section 5.

5. Results

Each of the subsections presented in this section corresponds to research questions. The first section 5.1 corresponds to RQ1 (first research question) and RQ2; the second section 5.2 corresponds to RQ3 and finally the third section 5.3 corresponds to RQ4.

5.1. Knowledge Management and Knowledge Management Views (RQ1 and RQ2)

This section seeks to answer the first two questions: Does the academic literature perform specific analyses for some of the views of knowledge management or does it deal with more general issues? and What are the views of knowledge management present in the academic literature?

Each of the 77 articles analyzed, is investigated if it deals with some of the knowledge management views proposed in the theoretical bases or if it deals with general issues. We found 41 papers presenting general issues and 37 papers dealing with some views. The distribution of views found is presented in table 4.

Table 4
Search Results for Knowledge Management View

View	Value
Individual	5
Organizational Aspects	7
Activities and Process	4
Technologies	25
Measurement	0

For each paper found with general issues es performed a detailed analysis for response the third research question: What general issues does the literature present? The method and results are presented in the next section. The papers found on the Technology view are analyzed in 5.4.

5.2. General Issues (RQ3)

For the papers found with general issues (41 articles) the method of analysis 5.2.1 and the synthesis of the analysis 5.2.2 are presented. Then some of the categories found in the analysis are treated individually in the following subsections. This section finds a response to the third research question.

5.2.1. Method of Analysis

For the analysis of the results obtained in the review presented in the previous section, an analysis with open coding is carried out, based on the systemic design for the qualitative research [31] and the procedures of Strauss and Corbin [32]. In the open coding, "all the segments of the material obtained for analysis are reviewed and it generates -by constant comparison- initial categories of meaning. It thus eliminates redundancy and develops evidence for the categories (raises the level of abstraction)" [31]. The categories are created from an interpretation of the data [33].

5.2.2. Synthesis of the analysis

Table 5 shows the categories found for the different studies analyzed. In [34] the detail of the analyzed articles and their categorization can be found here.

Table 5
Categories for General Issues

Category	Results
Innovation	10
Framework	6
ICT	5
case study	5
views	2
relationship: KM - 4IR	2
relationship: KM - software development	1
relationship: KM – Agile	1
relationship: KM - risk management	1
relationship: KM - Smart City	1
relationship: KM - Business Process	1
Ambidexterity	1
Performance	1
Practices	1
Collaborative innovation	1
Portfolio	1
Domains	1
strategic foresight	1
emerging technologies	1
Terminology	1
morphological framework	1
perceptions	1

The most discussed topics in the works found are innovation with some specific reference to collaborative innovation; these topics are detailed in 5.2.3 and 5.2.4, respectively.

The presence of frameworks or general models of knowledge management is common in the academic literature; they address general aspects of the subject and the identification of the components (called views in the theoretical bases of this article); similarly, the works are specifically linked to identifying views of knowledge management.

The relationship with information and communication technology (ICT) is addressed in different works already mentioned in this article that gave rise to the definition of technology as a view of knowledge management. Its specific approach is found in the articles that are analyzed in 5.3.

Several papers present the relationship of knowledge management with other disciplines (software development [35], agile [36], risk management [37], Smart City [38] and Business Process [39]) and with aspects of the technological revolution [40, 41]. In addition, specific case studies in different institutions are presented. Zanker and Bures [42] analyze the domains of knowledge management use in a systematic review of the literature and identify three groups: the first group is composed of Business, Education, and Managerial Disciplines; the second group, decision-making, Managerial Functions, Miscellaneous Knowledge Areas and Software Engineering; and the last group is a subset of models characterized by the fact that they employ KM KMP expressions while encapsulating domain knowledge. Linked to Software Engineering the authors propose references to Mishra and Mahanty [43, 44] and Jafari [45].

Other topics are addressed by only 1 article: ambidextery, performance, practices, portfolio, strategic foresight, emerging technologies, terminology, morphological framework, and perceptions.

5.2.3. Innovation

Organizational innovation is "the organization's capability to convert its human resources knowledge and integrate it to have new knowledge that produces a new product or a process" [46]. For [47], innovation refers "to a wide range of actions, products, and processes such as the improvement of administrative, planning, and programming systems, production processes, and the development of new products or the improvement of existing ones" and says that dissemination of knowledge facilitates innovation [47, 48].

The purpose of knowledge management is to offer innovation, so the relationship between these is often studied [49]. The knowledge dissemination affects innovative ability [50], there is a positive association between KM and innovation [51], and KM processes have a significant relationship with competitive strategy and innovativeness of firms [52]. The knowledge shared and transferred from multiple partners results in synergy for new knowledge creation and innovation performance [53, 54]. Zhang et al. [53] inquire about how knowledge to carry out technological innovation.

The KM literature considers innovation as a critical factor for companies in creating value and maintaining a competitive advantage in today's highly complex and dynamic environment [55, 56]; the application of knowledge would lead to innovation [57], a topic that is studied for [58] with evidence from academician workstations in China. [56, 59] investigate the impact of knowledge management practices (KMPs) on innovation performance.

The paper of Zhao [60] discusses the concept of dual innovation and the relationship between knowledge acquisition ability and dual innovation synergy.

[61] present a survey on a sample of 115 tourism lifestyle entrepreneurs, with the hypotheses tested about the relationship between innovation and KM using structural equations. For the authors, local knowledge plays an important role in TLEs' innovation and competitiveness because it is tacit and difficult to imitate [62, 63]. Hoarau [64] has recognized that generating and using (assimilating) new knowledge from external sources is an important predictor of innovation capacity. The fact that local knowledge acquisition affects its assimilation was also validated since it is through the acquisition of new knowledge that it is possible to transform the existing knowledge into innovation to produce a new concept within the organization.

Innovation is considered by some authors as an activity within the knowledge management process [65] and the relationship between innovation and knowledge management is studied by Gloet in his works [66, 67] and by Chaabane [68]. Gloet [66] presents the concept of Knowledge Innovation Management and the KIM Capability Model and defines the KIM as "the design, implementation, and review of social and technological activities and processes to improve the creation, sharing, dissemination, and use of knowledge to support innovation".

Knowledge sharing has a huge impact on the success of distributed innovation [35] y Companies that specialize in new product development (NPD) might profit from knowledge collecting by growing and increasing the quality of their offerings.

Finally, [46, 49] makes a very important survey on the relationship between knowledge management and innovation. It is the most specific work to trace the historical relationship between both aspects including references to [69, 70, 71] and exploring the empirical relationship of the effects of knowledge management on innovation following the contributions initiated by Darroch [72].

5.2.4. Collaborative Innovation

Zhang [53] proposes a new technological innovation paradigm based on collaborative manufacturing and open innovation; collaborative innovation refers "to a network innovation model based on interactions of multiple parties, by taking universities, enterprises, and research institutions as core elements and by considering government, financial institutions, intermediaries, innovation platforms, and nonprofit organizations as auxiliary elements" [53, 73]. This strategy facilitates knowledge flow and promotes learning from each other [53, 74, 75] through their participation in alliances.

5.3. Technology for Knowledge Management (RQ4)

For the papers found with technology view (25) the method of analysis 5.3.1 and the synthesis of the analysis 5.3.2 are presented and some of the categories found in the analysis are treated individually in the following subsections. This section finds a response to the fourth research question.

5.3.1. Method of Analysis

The different core technologies of each article are identified and categories are assigned according to the theoretical bases presented in 2.3.

5.3.2. Synthesis of the analysis

Table 6 shows the technologies (and knowledge representation) found for the different studies analyzed and their categorization. In [34] the detail of the analyzed articles and the technology for each paper.

Table 6
Technologies and their Categories

Technology	Category	Results
Ontology	techniques or models for knowledge explanation and representation	5
Artificial Intelligence	Fields of study 4	
Knowledge Graph	techniques or models for knowledge explanation and representation	3
Secure KM	Fields of study	2
Natural Language Processing	Fields of study	2
Knowledge Base	Technological tool	2
Machine Learning	Fields of study	1
Big Data	Fields of study	1
Wiki	techniques or models for knowledge explanation and representation	1
Decision Support System	Technological tool	1
IT platform analytics	Technological tool	1
KMS	Technological tool	1
Simulation	Organizational practices	1
learning management expert system	Technological tool	1
Mobile Technologies	Technological tool	1

The following sections deal specifically with those technologies that were found in more than 1 paper: Ontologies 5.3.3, Artificial Intelligence 5.3.4, Knowledge Base 5.3.5, Knowledge Graph 5.3.6, Natural Language Processing 5.3.7, and Secure Knowledge Management 5.3.8. In addition, papers were found related to Machine Learning [76], Big Data [77], Wiki [78], Decision Support System [79], IT platform analytics [80], KMS[81], Simulation [82], Learning Management Expert System [83] and Mobile Technologies [84].

The main categories for which results were found were the field of study, techniques or models for knowledge explanation and representation, and technological tools. A reference to an organizational practice was also found, while no results were found related to socialization techniques and logical and analytical processes.

5.3.3. Ontologies

An implementation of ontologies based on knowledge management is presented by Villamar Gomez [85] who describes a system for service robots that combines ontological knowledge reasoning and human–robot interaction to interpret natural language commands. The robot disambiguates uncertain requests through spoken interaction with the human before completing a task using information from ontological knowledge to create more precise questions. The paper presents various experiences with ontologies and especially ontologies for describing robots and uses the KnowRob framework, a framework designed to provide knowledge to totally autonomous robots that use the standardized description language Web Ontology Language (OWL). Wang [86] analyzed 1275 ontologies on the Web and found that most of them were in OWL; for [87] that OWL (Web Ontology Language) is the most widely used for ontology implementation too. OWL consists of three languages with increasing expressivity: OWL Lite, OWL DL, and OWL Full. All three of these languages allow you to describe classes, properties, and instances.

Spyropoulos [88] propose an Integrated Data-Driven Forensic Ontological Approach to Crime Scene Analysis defining an ontology as "a structured framework that defines the relationships between various entities and concepts within a particular domain" allowing for the representation of complex relationships that are machine-readable and intuitively understandable for human operators [89] y also proposing the use of OWL. For [77] an ontology "defines a description of concepts in a concrete domain (classes or concepts), properties of each concept describing various features and attributes of the concept (properties) and restrictions on properties", meanwhile for Sathiya [90] ontology is ideal for semantically representing knowledge by integrating and organizing it into a conceptual hierarchy; [77] proposes a BIGOWL ontology which is the result of ontology-driven approach to support knowledge management in Big Data.

Another case of ontology implementation can be found at [91] which proposes a framework for identifying and prioritizing Data Analytics (DA) opportunities. This framework has 3 components: a team of experts, DA Opportunity Knowledge Base, and prioritization tools, and proposes a collaborative knowledge management based on ontologies.

Finally, Gao et al. [92] is the main work associated with ontologies reviewing existing ontology-based KM tools that can support knowledge-sharing activities to provide helpful information for future research directions and presenting ontology-based knowledge systems [93, 94, 95, 96], repository [97] and sharing portal [98] and propose the concept of an ideal ontology-based knowledge management tools component and function.

5.3.4. Artificial Intelligence

Balaram [99] proposes a knowledge management architecture with artificial intelligence with 3 axes: management, users, and application. The management axis contains the sources to capture or acquire knowledge and the means of organization, the user's axis proposes strategies of socialization (share/learn) and knowledge transfer and finally, the application axis defines where to apply knowledge concerning sales, manufacture, and education. It mentions the use of artificial intelligence to help the knowledge management architecture, but it is not clear how it integrates it and what are the tools that should be used.

Some works present the relationship between Artificial Intelligence and Knowledge Management. Taherdoost et al. [100] examine the approaches in light of the literature that is currently accessible on AI and KM, focusing on articles that address practical applications and the research background. Liu and Li [101] show the Progress of Business Analytics and Knowledge Management for Enterprise Performance Using Artificial Intelligence and Man-Machine Coordination; and Li et al. [102] explore the application potential of HCI (human-computer interaction) technology under AI (artificial intelligence) in enterprise performance evaluation and the influence of abusive management and self-efficacy on enterprise performance.

5.3.5. Knowledge Base

Related to Knowledge Base, Park et al. [91] propose a framework for identifying and prioritizing Data Analytics (DA) opportunities including a component called DA Opportunity Knowledge Base, meanwhile [103] proposes a complex knowledge base question answering (C-KBQA) framework for intelligent bridge management based on multi-task learning (MTL) and cross-task constraints.

5.3.6. Knowledge Graph

Knowledge Graph is a concept proposed by Google in 2012. Knowledge graphs (KGs) organize data from multiple sources, capture information about entities of interest in a given domain or task (like people, places or events), and forge connections between them [104]. There are two types of knowledge graphs: general and vertical domain [105]. A novel marine science domain-based knowledge graph framework is presented in [106]. Ortiz Vivar et al. [107] propose a framework for academic knowledge management and research networking, which introduces a new perspective of integration combining information from multiple sources into a consolidated knowledge base and using knowledge graph-powered and Deng et al. [108] propose use of knowledge graph in Supply Chain Management.

5.3.7. Natural Language Processing

As mentioned in the ontologies section, Khadir et al. [87] describe a system for service robots that combines ontological knowledge reasoning and human-robot interaction to interpret natural language commands and successfully perform household chores. Arnarsson et al. [109] demonstrate a method using Natural Language Processing and document clustering algorithms to find structurally or contextually related documents from databases containing Engineering Change Request documents.

5.3.8. Secure Knowledge Management

Sahay [110] recognizes Secure Knowledge Management (SKM) as the science of security in the collection, organizing, and dissemination of knowledge; although the work does not address details associated with the theoretical bases of KM and the reference to IA prevails, it is relevant to consider this field of study to consider in the implementation of technology for knowledge management. Samtani et al. [111] says that "there are several key areas of cybersecurity and SKM that could be significantly enhanced through the development of novel AI-enabled analytics techniques" and include Cyber Threat Intelligence, Disinformation and Computational Propaganda, Security Operations Centers, and Adversarial Machine Learning to Robustify Cyber-Defenses.

6. Conclusions

The results obtained allow observing the relevance of knowledge management for innovation in organizations and artificial intelligence and ontologies as a fundamental part of the application of knowledge management.

It is proposed for future work to investigate the relationship between artificial intelligence and knowledge management and to propose points of integration between both fields of study; it is also expected to revalue the use of ontologies and to propose some ideas for their implementation, as well as to propose specific ontologies for the fields of action of the research group.

This work is relevant to the activities of the researchers as it allows the survey of the most important current issues present in the bibliography of the highest academic level. It is also important to highlight the absence of aspects of software architecture and software integration that account for the complex integration between the different technological elements. In future works, it is proposed to analyze and propose alternatives associated with the integration of components.

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