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The Theoretical Basis and Basic Principles of Knowledge Network Construction in Digital Libraries

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Abstract: Knowledge network construction (KNC) is the essence of dynamic knowledge architecture, and is helpful to illustrate ubiquitous knowledge service in digital libraries (DLs). The authors explore its theoretical foundations and basic rules to elucidate the basic principles of KNC in DLs. The results indicate that world general connection, small-world phenomenon, relevance theory, unity and continuity of science development have been the production tool, architecture aim and scientific foundation of KNC in DLs. By analyzing both the characteristics of KNC based on different types of knowledge linking and the relationships between different forms of knowledge and the appropriate ways of knowledge linking, the basic principle of KNC is summarized as follows: let each kind of knowledge linking form each shows its ability, each kind of knowledge manifestation each answer the purpose intended in practice, and then subjective knowledge network and objective knowledge network are organically combined. This will lay a solid theoretical foundation and provide an action guide for DLs to construct knowledge networks.

1.0 Introduction

A digital library is a knowledge system which collects, stores, distributes and preserves various digital objects such as text, images, video and audio, and enables them to be shared and managed across space and time to provide virtualized information services based on a computer network (Pyrounakis, Nikolaidou and Hatzopoulos 2017; Abdul and Mohezar 2020). However, with the explosive growth of information resources and the wide application of new information technologies, digital libraries are facing the dilemma of information overload (Li et al. 2019), information fragmentation (Guo, Zhang and Zhang 2017), information disorientation and insufficient context awareness (Jiang,Man and Wang 2022). In contrast, a knowledge network is a network-like knowledge system formed by taking knowledge units as nodes and internode association as chains (Zhu and Zhang 2020), focusing more on the relationship and interaction between knowledge entities (Guan, Yan and Zhang 2017). It has become an advanced stage of knowledge digitization carrier and a prerequisite for the emergence of a ubiquitous knowledge environment, being an inevitable demand for digital libraries to seek their own development and avoid existential crisis.

In order to obtain sustainable development in the ubiquitous knowledge environment, digital libraries need to organize various knowledge bases in a grid (Zhang et al. 2022) in order to create knowledge sharing platforms that can be accessed and applied interactively by users in a unified manner (Ricciardi, Cantino and Rossignoli 2021). In this way,

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the digital library can link the knowledge unit with the same, affiliated and related relationship in an orderly manner according to the inheritance and logic of knowledge nodes, in accordance with the inherent connection or certain needs, to constitute a knowledge network with orderly arrangement and structured organization, to promote the evolution of its own functions and the generalization of concepts, and to illustrate the systematic and organic construction of dynamic knowledge.

As a result, in this paper the linking mechanism of KNC was revealed comprehensively by studying the theoretical basis and basic principles of KNC in digital libraries, so as to provide support for the optimization and innovation of knowledge services in digital libraries.

2.0 Theoretical foundations of KNC in a digital library

The mechanism of building knowledge networks in digital libraries is based on the creative logic of convergence and transformation of knowledge (Abubakar et al. 2019), as well as the theoretical basis of the universality of the world, the phenomenon of small worlds, the principle of relevance, and the unity and inheritance of scientific development (Langer, Pedroni and Jäncke 2013). There is also the internal mechanism of organically connecting different knowledge units contained in different carriers of different subjects into a complete knowledge network by adopting the corresponding link technology due to the types and characteristics of the knowledge body and its association mode (Tóth and Apellaniz 2014).

2.1 The logic of knowledge creation based on explicit and implicit transformation

Everything in the world is universally connected, and knowledge, as the result of cognition of the state of motion of things and their regularity, is necessarily interlinked and forms a small world of knowledge networks. The SECI model of knowledge creation proposed by Nonaka and Takeuchi (1995) and others suggests that knowledge can only be created effectively through the convergent transformation process of socialization and externalization of tacit knowledge and the combination and internalization of explicit knowledge. This requires universal interpersonal connections in order to enable relevant knowledge to be inherited and unified by network associations, guaranteeing that people can use knowledge links as a tool for knowledge production and innovation, and supporting the construction of knowledge networks for the interconversion and integration of multiple types of knowledge resources in digital libraries. (Bolisani and Bratianu 2018; Bereznoy,Meissner and Scuotto 2021).

2.2 Knowledge links as a tool for knowledge production and innovation

The universal connection of the world is the starting point and theoretical basis to construct the knowledge network based on knowledge links.

Dialectical materialism believes that the world is a widespread contact and there are no isolated things and phenomena. All things, phenomena, process and its internal parts, elements, links in the world are interconnected and form the unified world interdependently and jointly. On the whole, the world can be divided into the external material world that includes things and people, the subjective knowledge world that reflects the consciousness, emotion, reason and intelligence of the cognitive subject, and the objective knowledge world that reflects the true description and content of objective things and phenomena based on human beings. These three worlds can be interrelated in the subjective cognition of human beings (Sun 2021). Knowledge as a result of cognition of the state of motion of things and their laws also needs to be linked in this universal association in order to form intricate knowledge links and constitute a complete knowledge network.

In the practice of knowledge activities, human beings undergo various forms of knowledge production and innovation through the links, thus further weaving and perfecting knowledge networks (Gadenne 2016). Any kind of new knowledge creation and production is accomplished on the basis of existing knowledge results through the knowledge links. In today's environment of knowledge economy, knowledge link is playing the role of a production tool to promote the function of knowledge production in social economy development through discovery based on data mining, ontology based on conception of formalization and the technology of latent semantic analysis of natural language processing. Knowledge linkage can carry out knowledge innovation activities in two forms; one is to link known knowledge to unknown knowledge through knowledge association, so that new knowledge in the objective knowledge world that has not been discovered before can continuously be discovered and applied by implicit association, and realize the further grasp of the subjective knowledge world to the objective knowledge world (Al-Ababneh 2020); the other is the linking of known knowledge into a knowledge network space through knowledge linkage, what Brooks calls a knowledge map, thus completing the understanding of the structure and properties of the objective knowledge world, and thus realizing the function of grasping the subjective knowledge world over the objective knowledge world. Thus it is said that knowledge linking is a production tool for knowledge innovation.

In the practice of building knowledge networks in a digital library, unknown knowledge could be acquired and transformed into known knowledge by knowledge link

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firstly, and then a new knowledge cyberspace can be built from known knowledge and newly unknown knowledge. Besides, unknown knowledge could be acquired through the extension of a knowledge network after constructing the network of known knowledge (Gadenne 2016). Both are knowledge acquisition and innovation based on the known knowledge of human beings and interact without the difference of succession.

2.3 Knowledge Network as the ideal goal of KNC

The "Six Degrees of Separation" experiment has justified the existence of the small-world phenomenon through practice. The small-world phenomenon essentially reveals the close correlation of human knowledge and information connection. No matter how large the world population is, how widely they distribute and how complex the organization and how large the number of nodes is, the shortest path can be achieved through access to relevant information. If the independent knowledge elements in the knowledge network are taken as nodes, they can be connected or integrated into identifiable and communication scope through limited paths (Langer, Pedroni and Jäncke 2013). Citation distribution and citation networks have already verified the small-world phenomenon in knowledge utilization. Knowledge networks in a digital library is a small-world of knowledge formed by its dynamic knowledge construction and is the logarithmic perspective of human knowledge production, which is to become the ideal target for DLs to illustrate knowledge construction and ubiquitous knowledge service (Jiang 2010).

2.4 Different disciplines can form a complete knowledge network

Science is a complete organism, which develops both uniformly and inheritancely. This phenomenon is reflected in the discrete distribution of knowledge and its documentation, which is one of the most prestigious Bradford's laws.

The unity of scientific development mainly manifested in integration, differentiation, crossing and penetration between different disciplines. On the one hand, subject differentiation is clearer and the number increases, which presents the obvious longitudinal trend of development. On the other hand, a lot of comprehensive disciplines, edge disciplines, interdisciplinary and cross-sectional disciplines are born in succession, which highlights the trend of horizontal integration, cross and penetration; it also makes natural science and social science complement each other and grow up together, because some major social issues need to combine modern science and technology and social science technology (Langer, Pedroni and Jäncke 2013).

Hence, the unity of scientific development, the highly integration, differentiation, crossover and penetration are increasing between disciplines, which are closely related to form a complete knowledge network.

Inheritance of scientific development is mainly manifested in accumulation and continuity of the same subject knowledge. Langer, Pedroni and Jäncke (2013) also point out that any scientific creation activity and knowledge production activity are innovation on the basis of knowledge accumulation and inheritance. In scientific research, inheritance and innovation are shown in the references of scientific knowledge by previous scientists. Scientific literature references and those being referenced is one of the important performances of scientific development law, which embodies the accumulation, continuity and inheritance of scientific knowledge, and also embodies the principle of the unity of science, enabling the present subjects contact each other, cross each other, namely mutual penetration (Langer, Pedroni and Jäncke 2013, Tóth and Apellaniz 2014).

In summary, there is both uniformity and inheritance in scientific development. The subject knowledge in each field is relatively independent and integrated by the various disciplines of the knowledge network, that is a related family and can constitute a complete scientific knowledge network for the user to make full use of and share with others.

2.5 Various knowledge linking method becomes the means of KNC

Any kind of knowledge structure is interconnected according to certain rules. Studying and revealing the rules and principles of knowledge network link is an effective basis to construct and make full use of the knowledge of the network.

There is a strong correlation between the knowledge, which makes network organization and integrated management of knowledge necessary and possible. All kinds of knowledge linking methods, whether based on citation or based on knowledge element, are to analyze the hierarchical structure and logical relationship of the knowledge content in literature through the relevance of knowledge, to find out the mutual influence and connection nodes of people's creation and thinking, and to establish the related connection between each other.

As a result of human cognition, Netto, Lima and Pierozzi Junior (2016) recognize that knowledge is abstracted and summarized through various concepts. The knowledge content of literature can only be expressed and revealed scientifically with a concept. In order to express a series of concepts and identification systems that summarize the contents of literature knowledge and their mutual relations, all kinds of knowledge linking mechanisms should be estab-

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lished on the basis of the concept of logic to build a knowledge network. According to different relationships of knowledge, concept logic is a scientific thinking method, which can reveal the nature of things and the relationships and differences between all things. The correlation of knowledge can reflect the relationship between the concepts, limit the extension of the connotation of the concept and categories the denotation, thus to build up mutually related and orderly knowledge networks. This knowledge link set up by knowledge correlations can reveal the correlation between concepts from the micro level and reveal the internal logic relationship between different knowledge units (Langer, Pedroni and Jäncke 2013). A correlation reveals the attributes of this logical correlation, which not only provides the principle and basis for the knowledge network link, but also provides various ways and methods for its realization.

3.0 The basic principle of KNC in digital libraries

The ultimate goal of KNC in DLs is to organize all the knowledge produced and created by human beings into a complete organic knowledge structure system, so as to realize the seamless link and interconnection of human knowledge. The scope of knowledge resources involved in the link of the knowledge network should cover both ancient and modern, accommodate all disciplines, include subjective/objective knowledge of all carriers, and cover various forms of knowledge existence and expression. It can be seen that the construction of KNC in DLs is very difficult, which requires the cooperation of link mechanism and form, so as to complete the knowledge network construction in an all-round way.

As the form and expression of knowledge is varied, different forms of knowledge require collaborative participation to connect all kinds of knowledge, thus to form various types of knowledge networks and converge into a unified integration.

3.1 All kinds of knowledge links perform all they can

In terms of the form in which knowledge exists, it can be divided into objective and subjective knowledge, which are respectively recorded in literature and carrier in the brain. So, according to the different objects, the way to construct a knowledge network is divided into three kinds by Zhou (2010): knowledge links between people, between the body of knowledge and people, and among the knowledge links themselves.

3.1.1 Subjective knowledge network construction based on interpersonal knowledge links

This form of knowledge linking is based on interpersonal communication and the exchange of ideas established by links forming subjective knowledge networks. This is an ancient form of knowledge link, and is one of the best ways for people to create an efficient interactive platform, and let people realize the function of link in it. The CNKI (China National Knowledge Infrastructure) knowledge sharing platform is used as an example to examine the knowledge linking mechanism based on interpersonal interaction.

CNKI knowledge sharing platform is a knowledge grid resource sharing platform established between users and information resources using an advanced grid technology and combining knowledge mining, intelligent agents, distributed knowledge base and other technologies, as shown in Figure 1. This platform can organize and manage knowledge grid services for core resource layer (CRL), operating system layer (OSL) and application system layer (ASL) respectively, and build up a resource grid, a knowledge grid and an user grid with knowledge base as the core and resource security sharing as the standard. Among them, the operating system layer consisting of a knowledge base management system, an application server (AS) suite and an enterprise manager can provide distributed heterogeneous integrated storage, unified access and security management for a personal digital library of each user by integrating CNKI series knowledge base, Internet resource integration knowledge base, joined knowledge base of various vendors and existing knowledge base of various institutions in the core resource layer. The application system layer can make use of information technologies such as a personal digital library, database building and publishing platform TPI, Internet information collection system 3I, automatic push, intelligent reference consultation IR, etc., to provide five kinds of knowledge grid service platforms integrating learning and research, knowledge service, knowledge management, network publishing and system management for different types of user groups interactively providing a complete solution for interpersonal collaborative knowledge link and instant communication to realize subjective knowledge network construction.

3.1.2 Construction of subjective and objective knowledge networks based on knowledge links between people and knowledge entities

This form of knowledge link can achieve knowledge acquisition and utilization through browsing, searching and questioning of network information, forming a knowledge network of subjective and objective knowledge fusion (Zhou 2010). Each of the three models emphasizes particu-
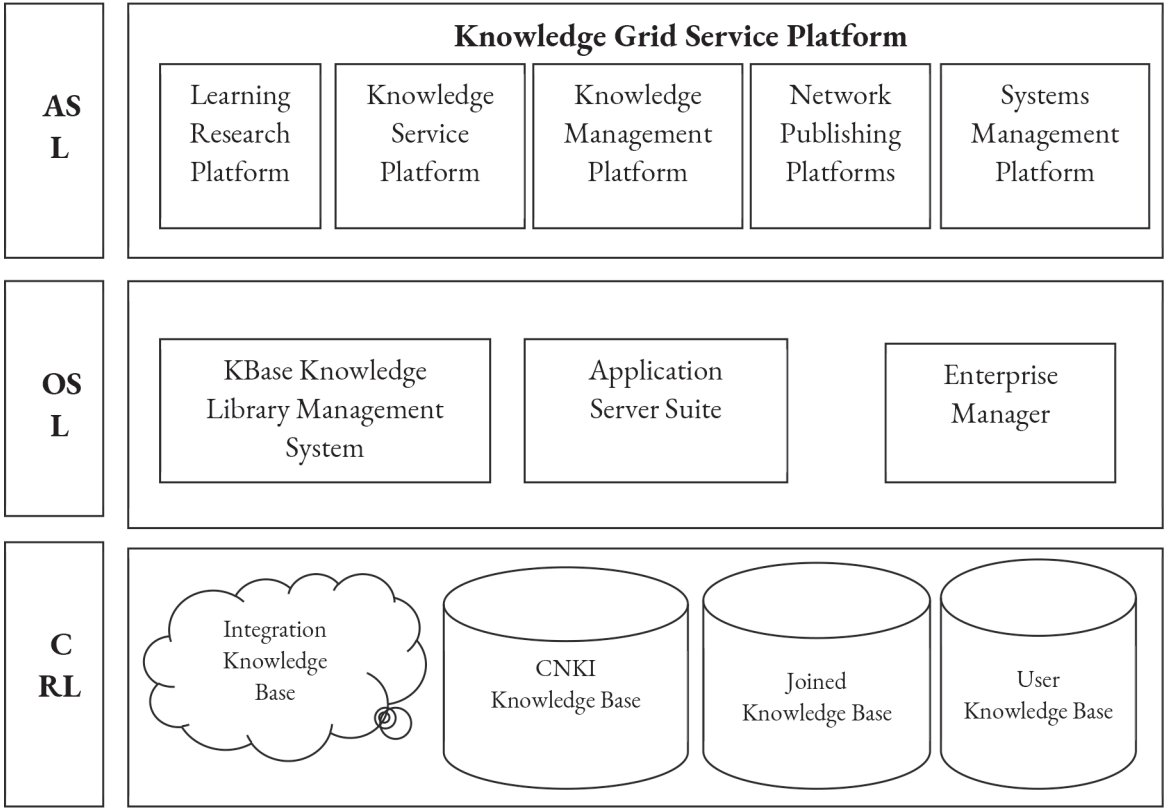
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Figure 1. Architecture of the CNKI Grid Resource Sharing Platform

larly on different aspects. The choice of a specific model depends mainly on the existing knowledge structure and the degree of understanding of the research topic of users. In general, browsing supports associative (predicative) learning and helps understand the information and knowledge acquisition well. It is suitable for the ambiguity of the subject matter in the pattern of the exploratory stage. Searching is aimed to get the information quickly. It is suitable for the clearing of subjects in the deepening and refinement research phase. While asking supports direct shortcuts to learning, aiming at specific problems in research topics (Zhou 2010; Kuusk and Gao 2015). Therefore, Zhou (2010) believes that asking is more appropriate to link knowledge at the basic level of knowing what it is; searching is better suited to quickly picking up clues to knowledge for further screening, linking knowledge at the level of what is known; browsing is more suited to in-depth query and analysis of information, linking knowledge at the level of knowing why and how.

With the advent of the era of the Web 2.0, the application of the Wiki system, which supports collaborative knowledge creation, promotes effective knowledge links between communities and knowledge sources, and the integration of subjective and objective knowledge network construction has unique advantages. Wiki is a complex adaptive knowl-

edge system, which can be regarded as a community of association, knowledge source, knowledge exchange and sharing, and knowledge co-creation from many perspectives. In this community, the Wiki platform can give full play to its characteristics of openness, self-organization, cooperation, simplicity and version control, showing the mechanism of self-organization of information and non-linear link of knowledge (Le Dinh et al. 2013; Garcia-Marco 2016). This enables Wiki communities to realize the social link of subjective knowledge through communication in the knowledge exchange and sharing process, and then to externalize objective knowledge and integrate knowledge sources. The knowledge items on the Wiki platform will also be combined into an objective knowledge network with the help of collective wisdom through the collaborative creation of the community, which will be internalized into the subjective knowledge of each community in the process of collaborative creation to improve the subjective knowledge network of the whole community. Such a cycle not only promotes the construction of objective knowledge networks among knowledge bodies, but also accelerates the construction of subjective knowledge networks within the community. Meanwhile, it promotes the convergence and integration of objective knowledge networks and subjective knowledge networks between knowledge sources and communities,

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thus forming a complete organic integration of knowledge networks and providing users with comprehensive and thoughtful knowledge link services. (Figure 2)

3.1.3 Objective knowledge network construction based on links to knowledge entities

This form of knowledge links is based on the correlation between knowledge. Because of the different types, granularity, manifestation and attributes of knowledge bodies, the link forms among knowledge bodies are the most complex. From macro to micro, the links between knowledge bodies can be divided as follows: based on the literature units of knowledge links (also known as reference links or citation links), based on the information units of knowledge links (also known as knowledge attribute link), and based on the knowledge units (also known as the logical links or semantic links) (Zhang, Sun and Yao 2017). These three forms of knowledge links can enable various types and attributes of knowledge to obtain comprehensive network links from large to small in granularity, from coarse to fine in form, and from surface to center in content,, which will certainly build a complete and objective knowledge network system for the digital library. The following is an analysis of the different objective knowledge networks constructed from the knowledge link mechanism applicable to each of the three main manifestation forms.

3.2 Each representation of knowledge is made full use of

With the development of the human knowledge management goal from knowledge carrier, knowledge attributes to knowledge content, the object of a knowledge link has also experienced the evolution from document unit, information unit to knowledge unit. In this process, knowledge organization and management is constantly deepened (Wang, Xia and Li 2019). Each of the three forms of knowledge construction has its advantages and should be made full use of.

3.2.1 Citation knowledge network construction based on literature units

Literature units are mainly applied to construct citation knowledge networks by reference links. They are the carrier of knowledge units, during which the main knowledge association is mainly manifested on mutual reference and being referenced. In the process of knowledge network construction of a digital library, the literature knowledge unit is more suitable for the reference link of knowledge and the construction of knowledge reference network. A citation unit based on the literature links is the most common and the most frequently used form of knowledge link, which allows users to have quick and direct access to relevant literature, and also enables them to know the origins of a research topic to meet their practical needs. But this knowledge link form is not accurate enough, sometimes requiring users to search the cited literature to identify and sum up the knowledge of the associated content of nodes.

The process of constructing knowledge network citation based on reference linking makes use of the open standards of links, determine the websites (URLs) and establish a citation index through literature citation relationships to the source bank. The corresponding target can be in articles, journals, dissertations, standards and patents, contents in books, conference, memos, index entries in abstract and even the links in the Website and Email, etc. (Finlay 2019). Through various types of citations in the literature, links are established between the abstract index and its cited literature, post-text references and the cited literature (Thelwall, Sud and Wilkinson 2012). Citation forward linking, citation back linking and co-citation clustering are based on three types of citations: cited, quoted and co-cited. The CNKI Knowledge Commons can link citations based on DOI's CrossRef, OpenURL-based SFX, and other methods (Wang et al. 2019).

– Mechanisms for citation linking based on DOI/CrossRef, OpenURL/SFX. Saier and Farber (2020) think specific reference links are established mainly relying on metadata
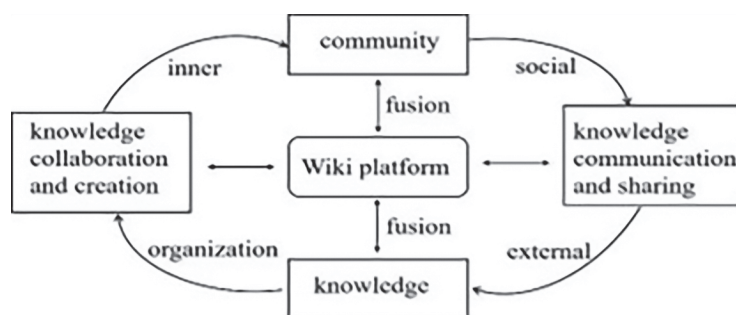

Figure 2. The knowledge linking model between people and knowledge based on the Wiki platform

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matching. There are corresponding metadata in both index reference and the reference. With the help of these metadata, links to digital library systems can only determine one target unit. To establish a reference link, the principle of matching metadata should be followed (Saier and Farber 2020): linking systems need to determine whether an abstract index record or a reference (represented by metadata) is the same document as another book or journal article. It is better to make them neither "missing matched" nor "false matched", and when both aspects cannot be considered, it is better to have a "missing matched" than a "false mismatched". As Noh, Ladd and Na (2015) point out, there is such a process regardless of whether they are based on DOI CrossRef or on OpenURL SFX. The working principle of CrossRef is: extracting metadata references, and then finding the matching in the CrossRef Center (of digital archives DOI logo and metadata) (Saier and Farber 2020). If the match is successful, a DOI unique identifier is placed in the URL of the reference link to guide the user to the full text of the corresponding electronic version of the reference(Young 2019). SFX extracts the metadata from the OpenURL containing the reference metadata and sends the metadata to the SFX (Service Component). According to the actual situation of the user's digital library, the appropriate link is generated by the SFX service component to carry out metadata matching (Kiran and Reddy 2018; Adamides and Karacapilidis 2020).

– Principles for the construction of the CKNI Citation Knowledge Network. In the construction process of knowledge network based on citation links, CNKI knowledge sharing platform can take each literature as a node, and when displaying its references, if the linking system finds the corresponding reference in the object resource library, it will establish a link on the reference of the text (Liu, Yang and Chen 2021). The linking system uses the source name, title, first author, volume and issue as the linking

rules to dynamically establish relevant links and guide users to view the citation information and follow the OpenURL standard links. Because OpenURL is embedded with standardized metadata information, it allows other literature service systems to parse OpenURL links and give corresponding processing results (Scott and Barton 2018), such as ProQuest, NSTL, Google and Baidu, etc. The linking system is highly open. In this way, CNKI can use each document as a node to build a citation network including references, citations, co-citations, secondary references and secondary citations through document links, and it can also display the reference and citation data of the document in each year separately. In Figure 3, an article (Jiang 2018) in *Studies in Science of Science* is used as an example to show the citation network of the article in the CNKI.

3.2.2 Construction of knowledge networks based on information units

An information unit is mainly used through characteristic knowledge units to implement attribute construction of knowledge networks. Information unit is a characteristic unit representing literature knowledge, which mainly refers to the appearance of characteristic information and content characteristic information of literature. Among them, the featured information includes title, authors, publishers and characteristics of related carriers. The external attributive knowledge network can be completely built by the database suppliers. Content information include abstract, theme words, keywords and reference in the word, phrase, sentence, paragraphs and reference. They are formed between the intrinsic attributes of knowledge networks. Due to the complexity and dynamic nature of the relationship, some knowledge links can only be established dynamically by the knowledge producer, such as a new knowledge discovery, and some knowledge links can only be established by domain experts, such as concept ontology.
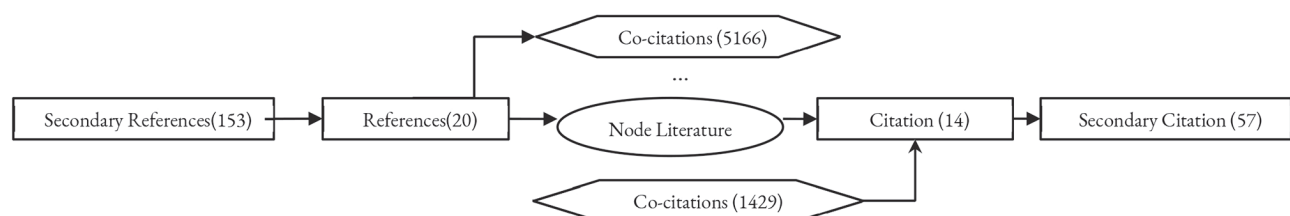
Citation Network

Figure. 3. Citation network of node documents on the knowledge network

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– Mechanisms for linking knowledge properties based on information units. An information unit plays the role of a bridge and link in the evolution process from a document unit to a knowledge unit. Each information unit in a descriptive document, such as keywords, theme keywords, is probably to be a node of knowledge or its name of the guiding information. Thus, a one-way link from the information unit to the knowledge unit can be established, which makes users go deep into the level of knowledge element to understand the corresponding information unit, so as to have a more detailed understanding of the literature unit from different information units and their knowledge elements, and then make the knowledge content with the same topic interrelated into the topic knowledge network.

Word frequency reflects the importance of information in knowledge units and the whole system through the subject relations. The subject relationship, topic structure and degree of association (such as co-occurrence frequency of subject words or keywords) among information units can be discovered through topic association. Through different combinations of information units, new knowledge units can be found (such as the links of subject words or keywords and their networks), and then the subject knowledge network can be constructed.

– The process of building a CNKI knowledge network. The main feature of this approach is the multidimensional attribute identification of knowledge bodies so that digital libraries can realize knowledge links across databases using the various attributes of knowledge bodies on a unified platform.

CNKI is designed to link the various attributes of the body of knowledge through the linking method of the "Knowledge Network Section". "Knowledge Network Section" is short for the knowledge information intersection node in the knowledge network. Various knowledge attributes of a document, such as detailed information and extended information of the main entity expressed in an article, can be used as knowledge nodes. Therefore, by clicking the various links on the knowledge network sections, the corresponding contents can be obtained and the knowledge can be linked by various attributes, thus realizing the disguised links among knowledge bodies, of which the specific knowledge attribute link points set are mainly the following: 1) author links-linking the papers or 2) author institution linking-linking papers and books published by this institution in multiple databases of CNKI; 3) keyword linking-linking papers and books with this word as the keyword in multiple databases of CNKI; 4) journal title linking-linking the basic information of the journal, the different eras of the journal included in the database of the knowledge network, the contents of each is-

sue of the bibliography, and some statistics of the journal; 5)journal links-linking the bibliography of the current issue in which the node literature is published.

It can be seen that a CNKI platform can use the detailed information and extended information browsing page of individual literature provided by China Periodicals Full Text Database as the "knowledge network section", which are multidimensional linked to the knowledge content of other series of databases in the China Knowledge Resources Database, such as the China Outstanding Master's Degree Thesis Full Text Database, the China Important Conference in the CNKI platform, based on the feature analysis of the multidimensional attributes of knowledge, to form multiple attribute types of knowledge network such as the author network, institutional network, citation network, project network, keyword network, classification network, subject literature network, citation literature network and related literature network and other. On the basis of similarity comparison, automatic clustering, citation analysis, association analysis and other theories, technologies and methods, it can automatically gather and dynamically illustrate the interconnection of knowledge on various attributes and generate knowledge association networks based on the characteristics of knowledge attributes.

3.2.3 Construction of logical knowledge networks based on semantic linking of knowledge elements

A knowledge element is mainly suitable for semantic links and contributes to the logic construction of knowledge networks. Nodes in the structure of a knowledge network can be in various states of knowledge existence and form, but only the knowledge element – the smallest unit of a knowledge structure – constitute the smallest node of a knowledge network so that they can play the role of knowledge acquisition, processing, regeneration and the functional implementation. The semantic linking can maintain inline and outreach of knowledge more accurately in the knowledge network. The internal semantic correlation of knowledge constitutes a knowledge entity, relying on the connotation of a knowledge element and builds the extension of relationship between units (Ensan and Du 2019). It can be seen that knowledge elements and their semantic links as a natural extension of current Internet hyperlinks (Guo, Jia and Zhang 2021) are like neurons, and their conducting nerves in the nervous system of the human brain play a unique role and service function. They can restore the true nature of knowledge connection, which is beneficial for the establishment of the platform of knowledge element, eliminate isolated information islands, build a new starting point and provide a powerful tool to discover and make use of knowledge and innovative knowledge.

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Jiang (2011) suggests that an independent knowledge element entity is composed of semantic content and semantic links. Wen and Jiao (2009) claim that the ontology of a knowledge element can effectively reveal the rich and complex semantic association within and between knowledge elements, thus separating the knowledge structure and content, making fully formalized description of semantic information, which makes contents form an understandable semantic formation in computer. The KNC is based on the semantic linking of knowledge elements, the key of which is setting up the structure of semantic links of ontology elements of knowledge and making semantic inter-connections. On the establishment of ontology structures, the ontology structure is described separately to be the internal structure of semantic content and the external structure of the semantic relationships, in which the internal structure (i.e. semantic content) is composed of the domain concept set and its corresponding attribute set and method set contained in the knowledge element ontology, and the external structure (i.e. semantic association) consists of the set of concepts and their corresponding relationships (Wen and Jiao 2009). Therefore, knowledge meta-ontology constructs a relatively perfect semantic content system of meta-knowledge through the attribute set and method set among concepts, and constructs an intricate and orderly network semantic association structure through the relation set among concepts, which provides a guarantee for the construction of knowledge network based on meta-knowledge semantic linking.

3.3 Make objective and subjective knowledge organic integration

The different linking way of knowledge mentioned above enables all links of objective knowledge networks to build a comprehensive system of knowledge networks. But the subjective knowledge contained in the brain can only link people and the body form of knowledge with the aid of knowledge and to construct a knowledge network.

Knowledge linking between people and knowledge entities requires an augmented reality environment and a platform to work efficiently. In the effective knowledge link between people and knowledge entities, the meta-universe can integrate the objective knowledge world, the external reality world and the subjective knowledge world into a ternary knowledge world based on the integration of brain-computer interface, virtual reality (VR), augmented reality (AR) and mixed reality (MR) technologies, providing a space for the sharing of user knowledge (Nagpal et al. 2021). Web 2.0 can provide various effective tools for people to link knowledge based on applications such as Blog, Wiki, Tag, SNS, RSS, IM, etc.; it enables user groups to share knowledge in a rich interactive experience (Alamäki, Dirin and Su-

omala 2021), adaptively participate in the production, dissemination and utilization of knowledge and information in the virtual-real knowledge world formed by the meta-universe, so that the subjective and objective knowledge of each other can be organically integrated by self-organized links in diversified, diverse, personalized and chemical interactions. From the formation of a blog knowledge exchange community to the collaborative organization and editing of Wikipedia, as well as the generation of social bookmarking groups and so on, the information self-organization function of Web2.0 and the link mechanism of the integration of subjective and objective knowledge are all embodied.

In the augmented reality environment formed by the integration of meta-universe and Web 2.0, each user is an individual network knowledge base with certain subjective and objective knowledge. Their integrated application brings a realistic opportunity for the fusion and linking of subjective and objective knowledge, so that the various applications of Web 2.0 can effectively support the need for the fusion and linking of various complex subjective and objective knowledge among user groups required for the construction of knowledge networks. The network community based on the overall effect, integrating various applications of Web2.0, builds a comprehensive scaffold technology of subjective and objective knowledge fusion, as shown in Figure 4 (Gamji et al. 2021).

In the environment of Web2.0, Gamji et al. (2021) agree that each user not only represents the personal web site, but also its individual network knowledge base in the application of Blog, RSS, Wiki, SNS, Bookmark, TAG process. User individual network knowledge base refers to the knowledge collection of network nodes centered on individual applications built by users in the above application process.

In figure 4, the basic unit of knowledge network link is the user's individual network knowledge base, which connects "Blog, Wiki, SNS", "BookMark" and "RSS" in three levels through Tag (Gamji et al. 2021). The inner level represents individuals communicating with each other through blogs, wikis, and SNS. Intermediary level indicates bookmark exchanges. The outermost level is the communication between subscription lists of RSS because sharing RSS reading lists is an inevitable trend from the development trend of knowledge network social technology.

In conclusion, in the environment of Web2.0, the fusion and link of subjective and objective knowledge are of variety in the diversiform and continuous development. All these goals of application are to improve the socialization of knowledge links, to follow and use some common technical specification for the correlation and flow of individual network knowledge bases.
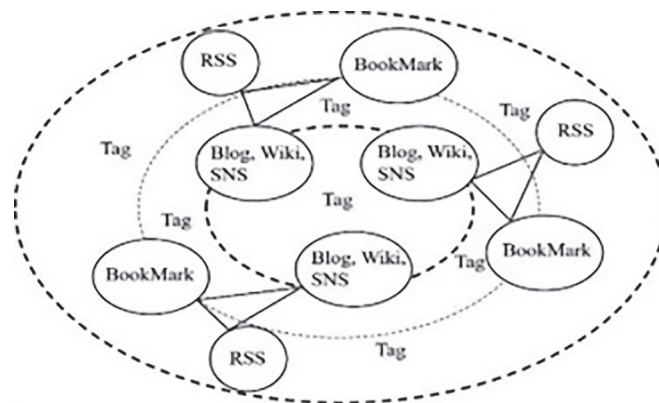
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Figure 4. The comprehensive frame of knowledge network based on the subjective and objective fusion

4.0 Conclusions

KNC is not only the inevitable demand for DLS to seek its own development, meet the challenge of knowledge economy in the future, and avoid facing the crisis of a ubiquitous knowledge environment, but also the strategic choice for the digital library to construct dynamic knowledge systematically and realize ubiquitous knowledge service from now on. As the essence of human knowledge production, knowledge link can objectively and truly reflect the relevance of knowledge structure, so KNC based on knowledge link can best reflect the true nature of the human knowledge structure system. It is not only supported by the universality of the world, the small-world phenomenon, relevance principles, and the unity of scientific development and inheritance of theoretical basis, but also accords with the law of development of scientific knowledge.

On this basis, this paper analyzed the characteristics of different types of knowledge link forms, and pointed out the ways of KNC that can be realized respectively. In addition, the appropriate way of knowledge linkage is found through the correlation analysis of different forms of knowledge. As a consequence, the basic principle of KNC in DLs is summarized as follows: let each kind of knowledge linking form each shows its ability, each kind of knowledge manifestation each answer the purpose intended in practice, and then the subjective knowledge network and the objective knowledge network are organically combined. This principle will push the digital library knowledge network closer to its practical application.

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