JKIICE

Journal of the Korea Institute of Information and Communication Engineering

링크드오픈데이터 기반 스마트 라이브러리의 참조모델에 관한 연구

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A study of Reference Model of Smart Library based on Linked Open Data

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요 약

최근 스마트 기술이 다양한 정보시스템 분야에 적용되고 있다. 특히, 기존 도서관 서비스 분야는 디지털도서관을 넘어 스마트 도서관으로 변화되었다. 이러한 변화의 환경에서 다양한 콘텐츠와 서비스 그리고 사용자와 스마트 디바이스를 지원하는 도서관 서비스 소프트웨어 플랫폼이 요구된다. 기존 도서관 서비스는 서로 다른 이기종의 도서관 시스템간의 의미적 상호운용성이 저해되는 제한점을 갖고 있다. 본 논문은 다양한 콘텐츠 제공과 시스템간의 상호작용 그리고 서비스의 통합에 중점을 두어 미래 도서관 시스템의 원형으로 링크드오픈데이터 기반의 스마트 라이브러리 제안한다. 링크드 오픈데이터 기반 스마트 라이브러리는 첨단 정보기술이 모여진 혁신적인 시스템이다. 우리는 링크드오픈데이터를 기반으로 스마트 라이브러리를 위한 다양한 요구사항에 따라 시스템 환경을 설계하였다. 이용자의 요구사항과 정보기술의 에코시스템을 고려하여 스마트 라이브러리 시스템의 기능적 요구사항에 대해 기술한다. 또한 기능적 요구사항을 수용하고 다양한 스마트 디바이스를 통해 사용자에게 스마트 지식 서비스를 제공할 수 있는 참조 프레임워크를 보여준다.

ABSTRACT

In recent years, smart technology has been applied to various information system fields. Especially, traditional library service area is changing to Smart-Library from Digital-Library. In this environment are need to library service software platform for supporting variety content, library services, users and smart-devices. Due to this, existing library service has a limitation that inhibits semantic interoperability between different heterogeneous library systems. In this paper, we propose Linked-Open-Data based smart library as an archetype of future-library system that provide a variety content and system interaction and integration of services. It is an innovative system of the cutting-edge information intensive. Therefore, we designed system environments according to various integration requirements for smart library based on Linked-Open-Data. And, we describe the functional requirements of smart-library systems by considering the users' demands and the eco-systems of information technology. In addition, we show the reference framework, which can accommodate the functional requirements and provide smart knowledge service to user through a variety of smart-devices.

Ⅰ. INTRODUCTION

The global dissemination of the multi-tenant, ubiquitous information gadgets such as smart phones, tablets and wearable devices linked with the Internet and the prevalence of smart information services has provoked the radical innovation of library systems. Obviously, library systems have been also transformed into e-library, digital library and semantic digital library according to the evolution of information technology [1, 2]. However, the recent smart information technology requests the fundamental innovation of library systems, not the adoption of digital information resources.

Library 2.0 inspired by Web 2.0 opens the new insight for library functions by means of openness, share, participation and collaboration through users networking. Digital Library (DL) has flourished the support of digitized resources through high-speed global networks to the diverse information appliances. It is very common to access knowledge services provided by DL elsewhere with smart mobile devices. Under this circumstance, semantic interoperability among knowledge services has become more important. To resolve the bottleneck of the proliferation of DL, semantic library using the common metadata and ontology, sometimes called Library 3.0, has been studied [3, 4]. A formalized standard representation schema for heterogeneous knowledge resources is necessary to realize semantic interoperability in the global network environment. Linked Open Data (LOD) widely used in public domains is applied into the library systems [5-7].

For the future library systems, a new innovative library system considering the requirements of library services as well as the eco-systems of information technology is required for the seamless evolution of library systems. This paper describes the referential model of Smart Library as an archetype of future library systems.

Ⅱ. Evolution of Library Information Systems

Since the main business objects of the library are knowledge resources, the library information systems are heavily influenced by means of the evolution of information. On the proliferation of electronic resources such as audio, images, videos and texts, electronic library (e-Library) has been appeared to manage electronic resources effectively. The library information systems also have rapidly evolved into the digital library aiming to realize integration and interoperability of information resources under distributed computing environment based on the Internet and computer networks. This kind of the transition of library information systems is to accommodate new library resources due to the innovation of information technology, neither the users' requirements nor the new service support. The purpose of e-Library or more generally digital library is to control electronically digitized information resources of various media and formats and provide service on open information access by establishing a large scale repository of electronic information resource. These systems still have used traditional management techniques such as MARC and metadata [7-10].

The Web technology accelerated open access of Web-based information resources and provided diverse services. Web 2.0 had proposed the ethos of Web technology that can be summarized into 4 important properties: openness, share, participation and collaboration through users networking. Library 2.0, the library information systems accommodating the ethos of Web 2.0, become the moment of the intrinsic transformation of library information systems. Library information systems are advanced towards user-oriented, service-oriented open systems.

Although library information services have been remarkably innovated, more intelligent information services are hindered by semantic interoperability among heterogeneous library systems.

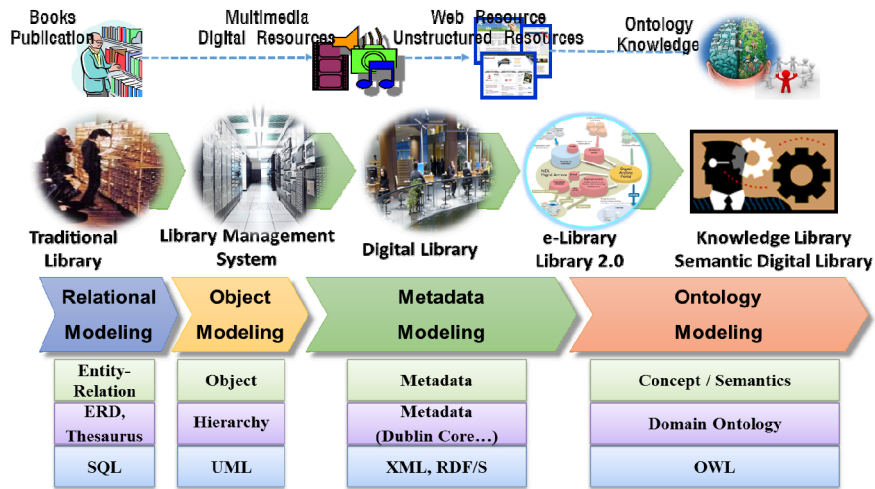For innovative service system and information

Fig. 1 The evolution of Library Management System

resources management, more fundamental approach is demanded. LOD originated from Semantic Web is applied to resolve these problems. Tripled-based description of knowledge resources in the library can be realized the global knowledge space by interweaved library information systems.

The evolution of library information systems shown in Fig. 1 have been was largely focused on providing various web-based services and interoperable description of knowledge resources. However, the seamless integration of related technologies are important and the innovated library information systems also consider the paradigm shift caused by smart mobile technology [7-10].

Ⅲ. A Reference Model of Smart Library Systems

Smart Library is an innovative system adopting recent information technology and an enhanced service system from the view point of a new library culture.

Consequently, it should offer the progressive functions that can accommodate a new technological, cultural transformation beyond the digital library. In this section, the functional requirements of Smart Library Systems are derived from the eco-system of the current smart information environment. And the referential architecture of Smart Library Systems is presented.

3.1. Functional Requirements of Smart Library Systems

Smart Library Systems are the convergence application of the forefront information technology from the point of view of the publication of smart services for knowledge resources in the library. Considering the users' demands and the eco-systems of information technology, the functional requirements can be summarized as follows:

3.1.1. Semantic-based services

Smart Library as an evolutionary model of the future library system can support not only the usual library business and user services but also the new functions that can be realized by means of the innovate information technology. Recently, library systems widely adopt metadata, ontology and FRBR. These conceptual models aim to realize federated business processes and semantic services. Linked Open Data is a very appropriate model for semantic-based library services in the global information environment.

3.1.2. Rich user experience

A rich user experience not just a simple information service should be provided. For example, the topic space related to a user's information search should be visualized for the effective navigation and provide related information resources such as movie, music and images. It is necessary to deliver diverse experiences that are valuable and meaningful for users using versatile devices.

3.1.3. Multi-place access

Library services should be available to the diverse devices without any restrictions. Considering the type of devices, library services have to be properly customized for devices.

3.1.4. Personalization

The library and information system should carry out a role as a personal information portal [8]. A personalized information portal should be realizable by utilizing service components including user profile, portlet or widget. Automatic subscription as RSS should be available. The library service cloud will be suitable for personalization and other user services.

3.1.5. Community support

Library community plays a key role for friendly interaction among library users, managers and developers. Various community activities including participation of users in cataloging, metadata tagging using folksonomy, information sharing through blogs and collaboration by means of wiki should be provided. In other words, library should be a shared knowledge portal that harnesses knowledge of the community. The community support is also important for library marketing.

3.1.6. Digital asset management

The first goal of the library and information system is at effective management of library and information resources. In Smart Library, not only the digital library information resources but also the core management information resources related to the library information system such as metadata, ontology, users profile and business rule specification should be effectively managed.

From the view of architectural and technical point, Smart Library can accommodate the cutting-edge technologies such as service-oriented architecture (SOA), cloud computing, ubiquitous computing, mobile computing and Internet-of-Things (IoT). Above all, semantic technology such as ontology and LOD will essential to implement the conceptual model of Smart Library. The architectural requirements can be summarized as follows by analyzing digital library management systems and library standards:

Knowledge resource network: Since the primary goal of the library is the management of the published knowledge resources, the efficient organization of knowledge resources are the basis of library systems. According to the advancement of information technology, the diverse knowledge resources have been newly advent and traditional resources are transformed into digital forms. To represent bibliographic information, various methods have been used such as metadata, thesaurus, taxonomy and ontology. However, LOD is widely accepted as a powerful enabler to realize semantic interoperability of knowledge representation of the hyper-connected knowledge resources. LOD is a new vehicle to represent and deliver bibliographic infor- mation in the global knowledge space [11-13].

Library business network: The library is transformed into the community center for knowledge concert from the traditional repository of knowledge resources. The library becomes the knowledge hub of cultural, educational and entertainment activities. Besides, the active user participation in library business is opened and encouraged. The library system should play a role of social network hub to provide knowledge activities and business participation of users.

Smart service network: The quality and diversity of information services as the product of the library should prove the justification of the unique role of the library,
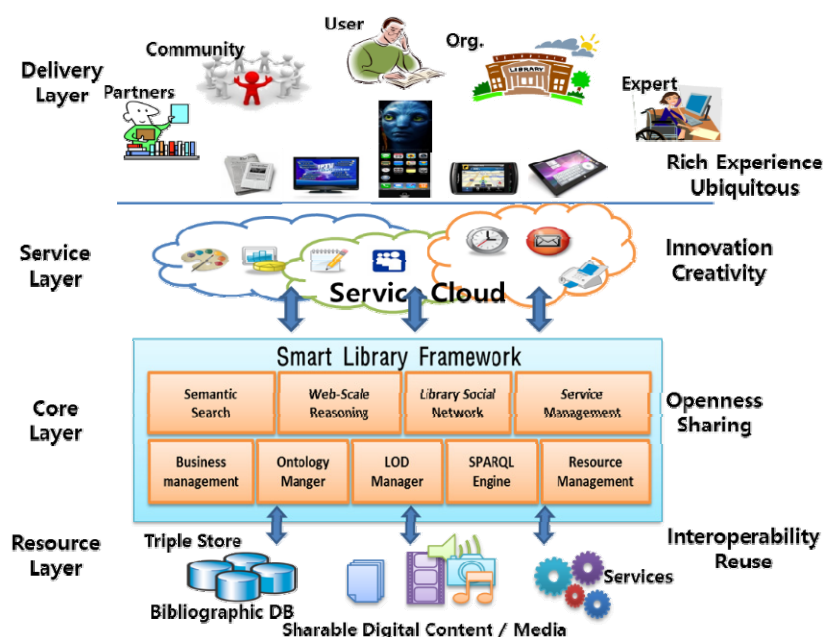
Fig. 2 Referential Architecture of Smart Library

compared with services provided by the Internet portals. The library systems should have the efficient information acquisition functions for their own business as well as offer ubiquitous smart services over smart devices. For the realization of smart library services, cloud computing is the essential infrastructure to develop sustainable services.

Technology network: Library information systems are indeed the convergence of information technologies. Library information systems need service-oriented architecture to implement business functions, cloud computing technology such as SaaS for the diverse services, ontology and Linked Data to represent semantically interoperable information, mobile computing to deliver smart services and ubiquitous computing for the efficient management of information resources. In addition to these, advanced network technologies are used for the infrastructure of library information systems.

3.2. Reference Framework of Smart Library Systems

The referential architecture of Smart Library Systems

consists of 4 layers: resource layer, core layer, service layer and delivery layer. This framework can be implemented with service-oriented architecture

3.2.1. Resource Layer

The resource layer is for the management of 3 major resources of library systems. Digital resources for the conventional library functions that usually manage digital library resources, triples of bibliographic LOD and library services components. The prominent properties of these resources are to supports semantic interoperability and reuse. The core layer consists of several components that can be classified into 3 categories. The most important thing in this layer is interoperability and reuse of bibliographic information.

3.2.2. Core Layer

The conventional library business functions are fully supported for the sustainable innovation of library systems in Smart Library. LOD management is to endorse the new paradigm of library systems to realize

the global knowledge network of library resources. In other word, semantic representation of bibliographic information is the most important thing to implement Smart Library. LOD representation and publication of bibliographic information can contribute for the federation of library system to realize global library network similar to the Internet. Several components such as LOD platform including triple storage, mapping tools to convert bibliographic database, search engine, RDF browser and SPARQL engine are indispensable subsystems. The core layer can support openness and information sharing for the global knowledge space that is the goal of Linked Data.

3.2.3. Service Layer

Library social network and service components are to support the diverse smart services for the users. Knowledge services are provided in service layer in the form of private or public cloud. The interoperability and integration should be guaranteed among services.

3.2.4. Delivery layer

The rich user experience of knowledge services are delivered through the diverse devices including mobile phone and tablet to realize ubiquitous services.

Since the main business objects of the library are knowledge resources, library information systems should have to use the cutting-edge information technology. Smart Library Systems are based on the innovative information technology such as cloud computing, ubiquitous computing, mobile computing, linked data and Big Data as shown in Fig. 2. Furthermore, since these technologies are at the level of practical applications, Smart Library Systems can be realized through the seamless integration in open system environment. The migration of the traditional bibliographic information into linked data, especially, has been accomplished in various ways [6, 7, 14, 15].

Ⅳ. CONCLUSION

This paper presents Smart Library Systems as a model of future library information systems. The library information systems are rapidly innovated by means of the evolution of information. Especially, smart computing leads the fundamental revolution of library information systems. Smart Library Systems can achieve the seamless integration of the cutting-edge information technology that bring the rich knowledge services into the library.

This paper analyses the functional requirements of Smart Library Systems by considering the users' demands and the eco-systems of information technology. The referential framework is proposed to accommodate functional requirements and provide smart knowledge services to the users in the global environment. Since Smart Library Systems are typical application of the technology convergence, it can be effectively implemented in open system environment.

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