User Behavior Model-Driven Personalized Services: A Survey

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Abstract

Personalized service represents an approach to optimizing information systems. The system introduces user behavior models for optimizing retrieval systems, information recommendation systems, workflow management systems, user-generated content systems, social network systems, media playback systems, network navigation systems, mobile communication information systems, and interactive panels. It explains the evolution from simple tool-based user models to technology-operation-based user models, and subsequently to user models that align with human psychology and behavior. A workflow of "user behavior - user modeling - personalized service - redesign" is proposed as a holistic solution for user behavior model-driven personalized services in digital libraries.

Full Text

Preamble

Research on Models of User Behaviour Driven Personalized Services

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Abstract: Personalized service is a way to optimize information systems. This paper systematically introduces user behaviour models for optimizing retrieval systems, information recommendation systems, workflow management systems, user-generated systems, social network systems, media player systems, web navigation systems, mobile communication information systems, and interactive panels. It explains the evolution from simple tool-based user models to technically operational user models, and then to models that align with human psychology and behaviour. A workflow of "User Behaviour–User Modeling–Personalized Services–Redesign" is proposed as a comprehensive framework for user behaviour model-driven personalized services in digital libraries.

Keywords: Ubiquitous intelligence; Information and Communication Technologies (ICT); User profile; Ontology; Semantic Web

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1. Introduction

Effective personalized services can create greater value for libraries while generating more employment opportunities for society. For instance, Naylor et al. (2008) conducted in-depth interviews with university students to investigate possibilities for enhancing real-time reference services, identifying user demand for expanded consultation services and the underlying rationale for personalized services [1]. Undoubtedly, digital libraries have long been moving toward personalized services, yet questions regarding what services to offer, how to improve efficiency, and how to enhance effectiveness remain ongoing concerns for information technology and service development.

Customer/user-oriented behaviours include predicting customer requirements, product explanations, customer education, emotional support, and providing personalized information [2]. Numerous studies demonstrate that technological products must integrate human psychology and behaviour to function effectively. In healthcare, marketing, and smart homes, for example, experiments show that personal attitude is the most crucial psychological factor in individualized and automated services [3]. Similarly, culture, product type, and price influence online consumer behaviour and marketing in personalized services [4]. In other words, effective information service systems must emphasize not only capacity expansion, speed improvement, and service diversification but also human-centered design and "personated" services.

How to combine computer technology with human psychology and behaviour represents a core challenge in current information technology. From the perspective of artificial intelligence history, strong AI remains elusive, while weak AI applications are limited (e.g., electronic games and household appliances). Deep knowledge computing, knowledge management, and knowledge services cannot rely entirely on AI technology; instead, they require "simple and feasible" approaches. Technically interpreted: "Humans can understand the meaning of information while machines cannot, but through machine-processable semantic data, the semantic web can utilize ontologies to read and process information, thereby integrating it into interoperable ubiquitous computing" [5]. In other words, leveraging the semantic web for multi-layered data exchange and using ontologies for limited reasoning processes to achieve interoperability among different data sources, applications, and information types represents a currently feasible technical approach to supporting personalized service standards, formats, and measures.

Although the semantic web supports data exchange and ontologies enable limited reasoning, the ultimate purpose of data exchange and the appropriate application of limited reasoning depend entirely on the architecture of the information service system. External design factors include law, policy, objectives, finance, and human resources, while internal factors encompass models, standards, and technology—namely, user modeling. In recent years, personalized service research has increasingly focused on "information technology experiments for information services based on web user behaviour." Particularly, the trend from information integration toward service differentiation emphasizes different users and their needs, the shared societies constructed by different users, and various types and methods of knowledge exploration and user services. In e-government, for example, Bonacin et al. (2009) recommend extracting parameters from simulated social environments in multi-user contexts to design system interactivity [11]. Such personalized services focus not only on presenting what information the government has but also on what information to present to whom. In e-commerce, Wang (2009) used K-clustering for outlier identification and robust segmentation to address product differentiation issues in customer needs [12]. The rationale is that different customers have different risk attitudes (the longer the time, the more likely recommendations are not what users need, and this temporal variance manifests differently across customers). Based on behavioural theory, suitable strategic, tactical, and operational models can be proposed for personalized recommendation services [13]. In summary, personalized service development has always been closely related to user behaviour exploration and user model improvement.

2. Progress in Digital Library Personalized Services

Personalized services originated from information needs in end-users' information-seeking behaviour: information is organized through some mechanism before and after searching to make information retrieval more efficient and information acquisition more convenient. Currently, various emerging information technologies have prompted experiments with different types of personalized services. For example, in information recommendation, Liao et al. (2009) built personalized ontologies from user borrowing records to filter information recommendations, supporting personalized information services in Chinese digital libraries [6]. In online reference consultation, Hwang et al. (2009) discussed blogs as new personalized media in terms of content creation, characteristics, and dissemination forms [7]. The concept and practice of personalized services have permeated traditional library operations, becoming part of digital libraries and transforming libraries' social functions and the relationship between readers and libraries. In ambient intelligence, for instance, personalized services embed information and communication technologies into personal, work, learning, and family life, emphasizing user-friendliness, empowerment, and support [8]. These technological and societal changes have driven transformations in digital library information services and their mechanisms.

Personalized service systems, as systems-of-systems (SoS), can enhance personalized services through user behaviour models. For example, in non-login environments, only resource attributes and click information can be used to judge user queries, so combining domain classification trees and information association graphs to filter information can optimize information recommendation effectiveness [9]. Similarly, user modeling for content retrieval personalization can achieve a good compromise between cost and practice [10].

3. User Behaviour Models in Personalized Service Systems

3.1 Information Retrieval System Optimization

First-generation retrieval system user models primarily focused on a linear "Begin–Query–End" process. Users' information behaviour outside the system, such as activities within library buildings, could be studied and explained through information-seeking behaviour. Second- and third-generation retrieval systems, or search systems like Yahoo portals and Google, feature user models centered on "Query, Second Query, Return, Click, Download, Browser Time" —lacking linear process characteristics but still constrained by system-defined user operational behaviour. Additionally, based on descriptive statistics of all terminal users recorded by the system, web search behaviour types can be identified and used as a basis for depicting user behaviour. This represents the user model currently adopted by most libraries and information resource integrators.

New-generation retrieval systems employ various additional features to enhance search results and improve efficiency. For example, incorporating ranking into retrieval systems and using rule-based search methods with subsequently ranked search results to set user preferences optimizes intelligent matchmaking for web service systems [14]. In personalized services, many user preference settings are added. For instance, Germanakos et al. (2008) integrated user profiles with users' affective preference characteristics (visual, cognitive, and emotional processes) to filter raw web content [15]. In Ughetto et al.' s (2008) view, personalization refers to what has been widely termed "user-adaptive systems" : allowing users to select their query vocabulary and employing missing querying algorithms to summarize usage results and improve query efficiency [16]. In other words, the meaning of user behaviour is not merely the steps for operating a system but is considered as "participating in or changing" retrieval result content.

To assist users in retrieving and managing information resources, digital libraries can adopt a "multi-agent selective dissemination of information" service model: the semantic web, fuzzy linguistic modeling technology to improve user-system interaction, natural language processing (NLP) to generate semi-automatic lexicons, and RSS feeds to generate personalized information announcements [17]. In this service model, user modeling is not the focus of technical practice but rather the focus of selecting technical practice. To achieve personalized service goals, users are first imagined as people without complete query capabilities or specific search formulas. Their information search behaviour depends on their interaction process with the information service system, including the system' s automatic calling of bibliographic data from other databases, proxy retrieval, and statistical compilation of search terms. Their information-seeking behaviour is also influenced by information recommendations to the currently browsed webpage and personal email. Future information retrieval systems will more likely reference user models and design schemes based on information-seeking behaviour and web search behaviour.

3.2 Information Recommendation System Optimization

In some literature, "personalized service" is almost equivalent to "information recommendation." Unlike information retrieval, information recommendation requires content selection, and each user' s selection differs, making a unified resource information service system appear to serve individuals specifically. For example, commercial websites rely on purchase and click history to learn user preferences and desires for product or information recommendation. Most personalized information recommendation systems integrate web usage mining, content-based and collaborative filtering, disaggregating product category catalogs through user preference variables, and more granular personalized information recommendation [18]. This recommendation is built upon grouping different user groups for product catalog distribution to reduce information volume and concentrate content. In short, information systems must analyze user behaviour before conducting user information services.

User modeling is evolving toward combining (logical) personal preference decision trees with (contextual) resource multi-attributes to optimize recommendation systems: improving recommendation accuracy based on user query history; calculating according to type relevance and temporal satisfaction of relevant contexts; and filtering resources for pre-recommendation [19]. The underlying technology for such personalized services includes: using network ontology languages to build RSS information push service architectures [20]; and selective dissemination of information (SDI) mode: semi-automatically designating matches through the semantic web for core vocabularies and related keywords and subject terms, using RSS content aggregation to generate personalized bibliographies for "latest announcements" [21].

This personalized service technology has developed into mobile communication content recommendation service systems: learning user usage logs and input items to judge user preferences; using Short Messaging Service (SMS) and Multimedia Messaging Service (MMS) for content recommendation; then analyzing user feedback on this personalized service and the relationship between SMS content provided by mobile service suppliers and user subscriptions to improve the system [22]. User behaviour is no longer passively receiving information recommendations after checking content item lists but includes active behaviour in providing feedback to improve information recommendations. Meanwhile, context-sensitive personalized recommendation systems integrate intelligent agents, radio frequency identification, semantic web, and other technologies to adjust the "need-awareness" prototype within systems [23]; enabling personalized services to conduct limited reasoning and information recommendation based on user behaviour calculation results—both a trend and a development priority.

3.3 Workflow Management System Optimization

From an information management perspective, first-generation information management systems primarily digitized documents and automated business processes, with high-end users completing work according to existing business models. Second-generation systems modularized business, allowing high-end users to reorganize, transfer, and assign tasks through management systems and delegating tasks to end-users. Third-generation systems aim for end-users to obtain results without understanding operational processes.

Personnel management systems are evolving toward personal data, indicator computation, and information integration. Koutkias et al. (2010) proposed a service-oriented information system framework for hypertension management, establishing a personalized long-term care health system connecting clinical sites and nursing area networks [25]; while Patrick et al. (2009) used SMS and MMS to remind users about weight loss methods, achieving good experimental results [26]. Such distributed computing systems can perform health management for patients and staff.

Business management systems are developing toward task instructions, matching computation, and workflow integration. Blobel (2010) designed personalized health services evolving from "organization-centered" to "process control" to "personal health," establishing mobile, pervasive, and autonomous computing for ubiquitous health services. This combines multiple disciplines including medicine, informetrics, biomedical engineering, biometrics, and omics, while addressing legal, administrative, regulatory, management, security, privacy, and ethical aspects, creating an architecture-centric, model-driven, formalized process system architecture [27].

In medical workflow management system development, there are already three modes: user operating systems, systems prompting users, and user-driven information computing and services. These modes, based on the semantic web and service-oriented architecture (SOA), can enhance business process management automation: designing hospital workflow management systems that understand knowledge objects through ontologies, including metadata prototypes for users, carriers, services, hospital assets, medical insurance, patient records, medications, and regulations [28]. In the future, conducting limited reasoning and information recommendation based on user behaviour calculation results is both a trend and development priority.

3.4 Web Navigation, User-Generated and Social Network System Optimization

Rich media streaming has transformed mass media user preferences. Personalized streaming services can distinguish time periods, user group ages, and genders, analyzing viewing records to identify target audiences for advertisements [29]. Due to information technology' s influence, communication theory' s definition of "audience" has shifted from "mass" to "community" to "group" to "individual," or personalized audience. Rich media streaming has developed not only in mass media but also in information technology applications. For example, Debrett (2009) discussed the pros and cons of diversification and personalization in public service broadcasting, arguing that new technology links "on-demand media services" with audiences, users, producers, and communities, with mixed societal impacts [30]. Additionally, rich media streaming has expanded to IPTV, mobile video, IP multimedia systems (IMS), and other platforms for personalized applications, adopting services that learn user configurations (preferences, interest domains, behaviour) for targeted advertising, personalized portals, content recommendation, and social networks [31]. Over the past decade, communication theory hotspots have evolved from "Bullet Theory" and "Agenda Setting" toward "Social Interaction/Network/Construction."

Thus, information service mechanisms based on user behaviour patterns have shifted from manual classification and resource presentation to machine-assisted classification, then toward assisting user browsing. In the manual classification stage, librarians classified, cataloged, and shelved materials, and the masses found information by browsing stacks or retrieval systems. In the machine-assisted classification stage, community users could have better browsing experiences. For example, Google News tracks user browsing keywords to capture relevant events. Chen et al. (2009) built upon this by combining an extension Chinese lexicon scanner and Chinese word segmentation system to develop a topic-tracking-based approach for Chinese digital newspapers [32]. However, truly considering user behaviour and characteristics—focusing on user behaviour and psychology for personalized services—represents a navigation system aligned with user interests. For example: inputting user interests, applying support vector machine (SVM) classification, eliminating low-usage preference variables, and mapping SVM classification with user attribute classification to form browsing navigation [33]; using taxonomic relations for user modeling, calculating user interests through domain ontologies and user models, and providing personalized information services on the semantic web [34]. Such services will develop alongside the continuous evolution of user behaviour.

Meeting user needs for content provision and effective content quality management has become a two-way challenge. Currently, personalized services can improve personalized search and content retrieval for user-generated content (pictures, videos, blogs, comments): learning user interests and stored personal retrieval content through decision trees and ontology-based user keyword models, supplemented by an algorithm to evaluate instant messaging service systems, then revising user interest matching and ontology parameters in the model for better matching [35].

User social behaviours such as participation, communication, and relationship formation have become social constructions in virtual worlds. To support such behaviour patterns, Kovacevic et al. (2008) introduced a hierarchical structure for distributed multimedia systems that senses location to optimize node-to-node communication performance and provides location-based multimedia creation and sharing services [36]. Sienel et al. (2009) designed an architecture (Open Platform for User-centric service Creation and Execution, OPUCE) covering event-driven seamless linking, user-created personalized service mashups, and community sharing [37]; this social network application combines Web 2.0, Session Initiation Protocol (SIP), and Peer-to-Peer (P2P) transmission to develop e-commerce personalization systems by integrating product and user data, forming a new knowledge service type: using sequence mining technology to classify user behaviour, forming user navigation models to develop predictive website navigation [38]; such services require deep understanding of user behaviour research to select frameworks for personalized service agents from user models in relevant studies, calculating user usage records in context-aware execution processes [39], or designing accessible and usable systems from ubiquitous web browsing devices (internet-capable phones) to establish user behaviour models [40]. In summary, a system combining web navigation, user generation, and social networks, applicable to mobile communication devices, depends on robust (accurate) user modeling.

3.5 Mobile and Playback System Optimization

The evolution of user behaviour models in mobile communication and media playback systems is evident, from early simple on/off controls to recent list selection/random playback using weak AI (primarily fuzzy theory), to novel systems that judge user behaviour and characteristics for playback.

As mobile phones and personal digital assistants (PDAs) increasingly overlap in functionality, digital value-added services for mobile communication become more important. As the foundation for mobile device services: encryption mechanisms (e.g., public key, key encryption systems, and digital signatures) and wireless and SQL technologies can already build real-time and reliable mobile ticketing systems [41]. On this basis, using mobile user time and location as conditional attributes, improved data mining algorithms can be developed to support fuzzy personal mobile patterns for personalized services in wireless communication networks [42, 43], making it possible to develop personalized services from user location and interests. Such services rely on judging user behaviour and characteristics: for example, using ubiquitous characteristics in ubiquitous environments for seamless linking in wireless networks, providing more granular personalized services from different locations and user attributes [40].

Radio frequency identification technology can not only strengthen parental controls for IPTV but also develop interactive personalized services for payment, usage feedback, and user generation [44]. In television broadcasting systems, Lopez-Nores et al. (2009) developed a streamlined semantic reasoning process to support preset user selection models, allowing digital TV to judge (learn to infer) who is watching to provide program forecasts, similar content and channels, and color and sound adjustments [45]. In music playback systems, Liu et al. (2010) designed automated music playlist services based on time parameters; the system's core uses artificial neural network computation on user ranking lists and usage time records to select and recommend music for users [46]. Chung (2009) et al. used data mining methods to propose an "adaptive personalization system" that can automatically download MP3 playlists to customers' mobile digital devices without users actively setting playlists [47].

Mobile and playback systems continue to converge. Users can use IP multimedia systems to access electronic service guides, video on demand, quickly switch channels, and use parental-controlled IPTV [48]; they can also use interactive mobile TV standard interfaces to access web interaction systems, establishing user behaviour models from account login systems. Personalized mobile multimedia services are neither bound by TV content nor service bundles, allowing acquisition and selection of different media content [49]. In short, designs that previously considered user operational convenience for playback and communication systems have shifted to providing users with playlist selection and personalized operations. However, more experiments show that considering user behaviour and characteristics is the best way to optimize such personalized service systems.

3.6 Interactive Panel Optimization

In the first stage, user differences were not very important. While users actively queried information to obtain it, they remained passive regarding information output. In the second stage, users could "select" within established frameworks, content, and lists, but still exhibited mass behaviour where information systems filtered recommended information for them (rather than filtering what they needed). The third stage represents truly user behaviour-driven personalized services. Currently, personalized services can gradually solve such problems, yet many challenges remain worth exploring.

Interaction is not only a main topic for information systems but also a key issue for personalized services. Interoperability between systems involves functionality and efficiency, while functionality depends on user needs; interactive performance between systems and users depends on content, structure, and purpose of user services. Interactive interfaces reflect designers' understanding of user behaviour and characteristics.

In the first stage, creating a good graphical user interface (GUI) to balance Quality of Service (QoS) and Quality of Experience (QoE) requires ensuring source reliability, data processing, and display functions, plus adding fully functional application modules for user participation [50]. However, a possible drawback is that different interfaces for different users complicate interface control management. To simplify complexity and reduce system control burden, Yoon et al. (2008) proposed two selective interaction modes: network scanning-based indirect interaction providing connections and filtering for network work environments; and camera-based direct interaction providing an intuitive interface as an input device. Users can repeatedly use these two modes to participate in and create personal panels [51]. Through autonomous creation of personal panels (typically just avatar design), users can enter creation environments (toolsets for user-oriented programming or content publishing) for personalized information output, query, or usage behaviour.

Personalized service system interactivity faces two challenges: creating user spaces for users and seamless linking services in ubiquitous environments. For the former, Service Creation Environment (SCE) adopts mashup 多元 service toolkits including: a simulation (verification) tool, runtime debugging tools, and system environments; it can provide personalized services for various users in different contexts [52]. For the latter, resource management with retrieval content permission settings uses distributed server architecture to support task allocation consuming massive computing resources, allowing users in ubiquitous environments to access information systems through mobile communication devices [53]. Combining these two service modes enables deep-level personalized services.

4. Conclusion

From the perspective of knowledge resource presentation, personalized services save readers' information-seeking time on one hand and reduce libraries' information organization costs on the other. Chang et al. (2006/2009) argue that if users frequently shift their interests, information indexes need restructuring; through data mining for regular information index reorganization, assigning different weights to each keyword and distinguishing users' long-term and short-term interests can reduce data update costs in the "user first proposes needs, then presents keyword groups, then webpages provide filtered information" service model [54]. In other words, data exchange between different media, information sources, and institutions, along with service procedure mobilization, has become an important topic. Currently, the information organization architecture provided by the semantic web can theoretically overcome such problems.

However, personalized services not only change the structure and mode of electronic resource presentation but also move toward precise information recommendation models, with substantial related ontology research and several practices. Most importantly, personalized services change service thinking. People (behaviour, attitudes, values), processes (collaboration, characteristics, customization), and products (software, hardware, infrastructure) are core elements of information service systems [55], with people being the core element. For example, developing next-generation e-learning systems can begin by analyzing and describing formal (teacher-guided) and informal (student-led) learning environment architectures to create Web 2.0-related services that provide personalized interfaces [56]. Examining the purpose of personalized services reveals they aim to improve information service system efficiency, effectiveness, and adaptability; therefore, the main work in personalized service practice lies in system lifecycle, human-computer interface, and system integration, while theoretical content includes service strategy, tactics, and operational directions, organizational data, modeling and control, plus component design, interfaces, and testing.

A driver is a small piece of code in an operating system containing hardware device information that enables computers to communicate with independent devices. As a driver model, the user behaviour model aims to effectively connect program modules from user models to guide information presentation and mobilization. Different software operating systems require different hardware drivers, and hardware manufacturers continuously upgrade drivers to ensure compatibility and enhance functionality; similarly, user behaviour models have different emphases for different service mechanisms and also require continuous upgrading. User behaviour models are crucial for effective practice in digital library technology because multifunctional information services in complex environments need an operations center-like program, and various application implementations also require service process design.

Therefore, this paper finally recommends the "User Behaviour–User Modeling–Personalized Services–Redesign" workflow as a practical framework for adopting new technologies and implementing user behaviour model-driven digital library personalized services. User behaviour models must consider all possible activities, characteristics, and states, while user modeling accurately optimizes (balances) user behaviour models and information technology applications; the resulting personalized service user needs, user-needs, and user-requires constitute the development theory, foundation, and basis for new-generation information systems.

References

[1] Naylor S, Stoffel B, Van Der Laan S. Why isn' t Our Chat Reference Used More? Finding of Focus Group Discussions with Undergraduate Students[J]. Reference & User Services Quarterly, 2008, 47(4): 342-354.

[2] Rafaeli A, Ziklik L, Doucet L. The Impact of Call Center Employees' Customer Orientation Behaviors on Service Quality[J]. Journal of Service Research, 2008, 10(3): 239-255.

[3] Kwon O. Psychological Model Based Attitude Prediction for Context-aware Services[J]. Expert Systems with Applications, 2010, 37(3): 2477-2485.

[4] Moon J, Chadee D, Tikoo S. Culture, Product Type, and Price Influences on Consumer Purchase Intention to Buy Personalized Products Online[J]. Journal

of Business Research, 2008, 61(1): 31-39.

[5] Kim TJ, Kim MC. Context Awareness Using Semantic Web Technology in the Ubiquitous Learning Service[M]. New York: Annals of the New York Academy of Sciences, 2008: 501-515.

[6] Liao SC, Kao KF, Liao IE, et al. PORE: A Personal Ontology Recommender System for Digital Libraries[J]. Electronic Library, 2009, 27(3): 496-508.

[7] Hwang J, Lee Y, Kim S. Modelling Weblog Success: Case of Personalized Media in Korea[J]. Journal of Universal Computer Science, 2009, 15(8): 1589-1606.

[8] Li X, Feng L, Zhou LZ, et al. Learning in an Ambient Intelligent World: Enabling Technologies and Practices[J]. IEEE Transactions on Knowledge and Data Engineering, 2009, 21(6): 910-924.

[9] Weng LK, Zhang YX, Zhou YZ, et al. A Joint Web Resource Recommendation Method Based on Category Tree and Associate Graph[J]. Journal of Universal Computer Science, 2009, 15(12): 2387-2408.

[10] Bjelica M. Experiment with User Modeling for Communication Service Retrieval[J]. IEEE Communications Letters, 2008, 12(10): 797-799.

[11] Bonacin R, Baranauskas MCC, Liu KC, et al. Norms-based Simulation for Personalized Service Provision[J]. Semiotica, 2009, 175(1-4): 403-428.

[12] Wang CH. Outlier Identification and Market Segmentation Using Kernel-based Clustering Techniques[J]. Expert Systems with Applications, 2009, 36(2): 3744-3750.

[13] Chiu DKW, Leung HF, Lam KM. On the Making of Service Recommendations: An Action Theory Based on Utility, Reputation, and Risk Attitude[J]. Expert Systems with Applications, 2009, 36(2): 3293-3301.

[14] Choi O, Han S. Personalization of Rule-based Web Services[J]. Sensors, 2008, 8(4): 2424-2435.

[15] Germanakos P, Tsianos N, Lekkas Z, et al. Capturing Essential Intrinsic User Behaviour Values for the Design of Comprehensive Web-based Personalized Environments[J]. Computers in Human Behavior, 2008, 24(4): 1434-1451.

[16] Ughetto L, Voglozin WA, Mouaddib N. Database Querying with Personalized Vocabulary Using Data Summaries[J]. Fuzzy Sets and Systems, 2008, 159(15): 2030-2046.

[17] Morales-Del-Castillo JM, Pedraza-Jimenez R, Ruiz AA, et al. Semantic Model of Selective Dissemination of Information for Digital Libraries[J]. Information Technology and Libraries, 2009, 28(1): 21-30.

[18] Albadvi A, Shahbazi M. A Hybrid Recommendation Technique Based on Product Category Attributes[J]. Expert Systems with Applications, 2009, 36(9): 11480-11488.

[19] Luo JZ, Dong F, Cao JX, et al. A Context-aware Personalized Resource Recommendation for Pervasive Learning[J]. Cluster Computing, 2010, 13(2): 213-239.

[20] Chen CF, Wu ZQ, Ran CJ, et al. A Dynamic RSS Information Push Service Mechanism Based on Ontology of User Information Needs[J]. Electronic Library, 2009, 27(2): 222-236.

[21] Peis E, Herrera-Viedma E, Morales-del-Castillo JM. A Semantic Service Model of Selective Dissemination of Information (SDI) for Digital Libraries[J]. Profesional DE LA Informacion, 2008, 17(5): 519-525.

[22] Choeh JY, Lee HJ. Mobile Push Personalization and User Experience[J]. AI Communications, 2008, 21(2-3): 185-193.

[23] Kwon O, Choi S. Applying Associative Theory to Need Awareness for Personalized Reminder System[J]. Expert Systems with Applications, 2008, 34(3): 1642-1650.

[24] Toninelli A, Corradi A, Montanari R. Semantic-based Discovery to Support Mobile Context-aware Service Access[J]. Computer Communications, 2008, 31(5): 935-949.

[25] Koutkias VG, Chouvarda I, Triantafyllidis A, et al. A Personalized Framework for Medication Treatment Management in Chronic Care[J]. IEEE Transactions on Information Technology in Biomedicine, 2010, 14(2): 464-472.

[26] Patrick K, Raab F, Adams MA, et al. A Text Message-based Intervention for Weight Loss: Randomized Controlled Trial[J]. Journal of Medical Internet Research, 2009, 11(1): 6.

[27] Blobel B. Architectural Approach to eHealth for Enabling Paradigm Changes in Health[J]. Methods of Information in Medicine, 2010, 49(2): 123-134.

[28] Dang JB, Hedayati A, Hampel K, et al. An Ontological Knowledge Framework for Adaptive Medical Workflow[J]. Journal of Biomedical Informatics, 2008, 41(5): 829-836.

[29] Lim J, Kim M, Lee B, et al. A Target Advertisement System Based on TV Viewer' s Profile Reasoning[J]. Multimedia Tools and Applications, 2008, 36(1-2): 11-35.

[30] Debrett M. Riding the Wave: Public Service Television in the Multiplatform Era[J]. Media Culture & Society, 2009, 31(5): 795-811.

[31] Aghasaryan A, Betge-Brezetz S, Senot C, et al. A Profiling Engine for Converged Service Delivery Platforms[J]. Bell Labs Technical Journal, 2008, 13(2): 93-103.

[32] Chen CM, Liu CY. Personalized E-news Monitoring Agent System for Tracking User-interested Chinese News Events[J]. Applied Intelligence, 2009, 30(2):

121-141.

[33] Yuan JL, Yu Y, Xiao X, et al. SVM Based Classification Mapping for User Navigation[J]. International Journal of Distributed Sensor Networks, 2009, 5(1): 32.

[34] Jiang X, Tan AH. Learning and Inferring in User Ontology for Personalized Semantic Web Search[J]. Information Science, 2009, 179(16): 2794-2808.

[35] Strobbe M, Van Laere O, Dauwe S, et al. Interest Based Selection of User Generated Content for Rich Communication Services[J]. Journal of Network and Computer Applications, 2010, 33(2): 84-98.

[36] Kovacevic A, Heckmann O, Liebau NC, et al. Location Awareness-Improving Distributed Multimedia Communication[J]. Proceedings of the IEEE, 2008, 96(1): 131-142.

[37] Sienel J, Martin AL, Zorita CB, et al. OPUCE: A Telco-Driven Service Mash-Up Approach[J]. Bell Labs Technical Journal, 2009, 14(1): 203-218.

[38] Chou PH, Li PH, Chen KK, et al. Integrating Web Mining and Neural Network for Personalized E-commerce Automatic Service[J]. Expert Systems with Applications, 2010, 37(4): 2898-2910.

[39] Hong JY, Suh EH, Kim J, et al. Context-aware System for Proactive Personalized Service Based on Context History[J]. Expert Systems with Applications, 2009, 36(4): 7448-7457.

[40] Kim YB. Accessibility and Usability of User-centric Web Interaction with a Unified-Ubiquitous Name-based Directory Service[J]. World Wide Web, 2010, 13(1-2): 105-120.

[41] Chen CL, Lai YL, Chen CC, et al. Construction of a Real-Time and Secure Mobile Ticket System[J]. Journal of Information Science and Engineering, 2009, 25(3): 807-825.

[42] Hong TP, Huang CM, Horng SJ. Discovering Fuzzy Personal Moving Profiles in Wireless Networks[J]. Applied Soft Computing, 2009, 9(2): 667-676.

[43] Huang CM, Hong TP, Horng SJ. Discovering Mobile Users' Moving Behaviors in Wireless Networks[J]. Expert Systems with Applications, 2009, 36(8): 10809-10814.

[44] Jabbar H, Jeong T, Hwang J, et al. Viewer Identification and Authentication in IPTV Using RFID Technique[J]. IEEE Transactions on Consumer Electronics, 2008, 54(1): 105-109.

[45] Lopez-Nores M, Blanco-Fernandez Y, Pazos-Arias JJ, et al. Receiver-side Semantic Reasoning for Digital TV Personalization in the Absence of Return Channels[J]. Multimedia Tools and Applications, 2009, 41(3): 407-436.

[46] Liu NH, Hsieh SJ, Tsai CF. An Intelligent Music Playlist Generator Based on the Time Parameter with Artificial Neural Networks[J]. Expert Systems with

Applications, 2010, 37(4): 2815-2825.

[47] Chung TS, Rust RT, Wedel M. MyMobileMusic: An Adaptive Personalization System for Digital Audio Players[J]. Marketing Science, 2009, 28(1): 52-68.

[48] Mas I, Berggren V, Jana R, et al. IMS-TV: An IMS-based Architecture for Interactive, Personalized IPTV[J]. IEEE Communications Magazine, 2008, 46(11): 156-163.

[49] Gil A, Fraile F, Ramos M, et al. Personalized Multimedia Touristic Services for Hybrid Broadcast/Broadband Mobile Receivers[J]. IEEE Transactions on Consumer Electronics, 2010, 56(1): 211-218.

[50] Srbljic S, Skvorc D, Skrobo D. Widget-Oriented Consumer Programming[J]. Automatika, 2009, 50(3-4): 252-264.

[51] Yoon H, Woo W. Design and Implementation of a Universal Appliance Controller Based on Selective Interaction Modes[J]. IEEE Transactions on Consumer Electronics, 2008, 54(4): 1722-1729.

[52] Kim SK, Shin YM, Yu CR, et al. Integrated Service Creation Environment for Open Network Services[J]. Annals of Telecommunications, 2008, 63(3-4): 167-181.

[53] Park E, Nam HS. A Service-Oriented Medical Framework for Fast and Adaptive Information Delivery in Mobile Environment[J]. IEEE Transactions on Information Technology in Biomedicine, 2009, 13(6): 1049-1056.

[54] Chang YI, Shen JH, Chen TI. A Data Mining-based Method for the Incremental Update of Supporting Personalized Information Filtering[J]. Journal of Information Science and Engineering, 2008, 24(1): 129-142.

[55] Tien JM. Services: A System' s Perspective[J]. IEEE Systems Journal, 2008, 2(1): 146-157.

[56] Munoz-Organero M, Munoz-Merino PJ, Kloos CD. Personalized Service-Oriented E-learning Environments[J]. IEEE Internet Computing, 2010, 14(2): 62-67.

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Note: Figure translations are in progress. See original paper for figures.