

## Preface

The existence of large volumes of globally distributed information and the availability of various computing devices, many of which are mobile, present the possibility of anywhere-anytime access to information. This enables individuals and organizations to coordinate and improve their knowledge over various autonomous locations. However, the amount and nature of information can result in overload problems, in heterogeneity of formats and sources, in rapidly changing content, and in uncertain user information needs. Individuals and organizations may thus be faced with increasing difficulty in finding the “right information” in the “right format” at the “right time.”

In an already classic paper, Imielinski and Badrinath (1994) presented the trends and challenges surrounding mobile computing, which they said held the promise of access to information “anywhere and at any time.” The idea was that mobile or nomadic computing was possible thanks to mobile computers having access to wireless connections to information networks, resulting in more collaborative forms of computing. What Imielinski and Badrinath presented as challenges continue to be critical issues in the development of mobile applications and information services today. They pointed at heterogeneity as a result of the massive scale of mobile environments, they mentioned the need for dynamic reconfiguration of services in response to client mobility, and they reminded us of the privacy and security implications of mobility. Consequently, they argued that mobility would have far-reaching consequences for systems design, and indeed they were right. This book finds motivation on those issues, focusing on the subject of information retrieval and access—personalization in particular.

Chapters IV, VII, and X of this book explicitly address mobility challenges and propose ways to deal with them. Mobility is currently tied, from a telecommunications perspective, with next-generation wireless technologies that promise ubiquitous networking and mobile computing on a large scale, providing high-bandwidth data services and wireless Internet (Pierre, 2001). This can be grouped under the term “mobile next-generation networks (NGNs)” (Huber, 2004), which refers to the convergence of the Internet and intranets with mobile networks and with media and broadcasting technologies (Universal Mobile Telecommunication System, or UMTS, among them). Mobility can be defined as the ability to access services, normally accessible in a wired manner, from anywhere (Pierre, 2001). Mobile computing uses such mobility to allow users of portable devices to access information services through a shared infrastructure, regardless of location or movement (Pierre, 2001). Mobility can be further specified into the following types:

- **Terminal mobility:** The ability to locate and identify mobile terminals as they move, to allow them access to telecommunication services (Pierre, 2001).

- **Personal mobility:** Centers around users carrying a personal unique subscription identity and the system's capability to provide services according to the user profile (El-Khatib, Zhang, Hadibi, & Bochman, 2004; Pierre, 2001).
- **Service mobility:** The capacity of a network to provide subscribed services at the terminal or location determined by users (Pierre, 2001); this allows the possibility of suspending a service and resuming it on another device (El-Khatib et al., 2004).

Ubiquitous computing, for some the next wave after the "Internet wave," uses the advances in mobile computing and integrates them with pervasive computing, which refers to the acquiring of context from the environment to dynamically and accordingly build computing models (Singh, Pradkar, & Lee, 2006). The result is a global computing environment that is defined as ubiquitous computing. This novel computing paradigm has the goal of embedding small and highly specialized devices within day-to-day environments so that they operate seamlessly and become transparent (invisible) to offline or online users (Singh et al., 2006; Huber, 2004). Ubiquitous computing integrates several technologies, which include embedded systems, service discovery, wireless networking, and personal computing (El-Khatib et al., 2004).

Research in ubiquitous computing has shown three main focuses: (1) how to provide users with personalized information or services based on users' profiles, (2) how to provide services or devices with context-awareness ability to adapt the service behaviors or device behaviors according to various situations, or (3) a combination of the above. Therefore, personalization and context-awareness are of special importance for the development of ubiquitous computing.

Personalization reflects a design philosophy that focuses on the delivery of a contextual user experience (Hyldegaard & Seiden, 2004). Personalization, in the context of ubiquitous computing, is generally meant to denote the ability to customize the user interface, the information content, the information channels, and the services provided according to the individual user's needs, personal interests, and preferences (Hyldegaard & Seiden, 2004). Adding personalized functions into Internet-enabled information retrieval and access applications—for example, search engines or e-services—is becoming one of the competitive advantages used to attract users to survive in the current competitive business world. There are several personalization strategies, such as interface personalization, link personalization, content personalization, and context personalization. Personalization models, methods, and techniques built based on solid mathematic foundations and advanced programming languages are studied in the field, with the aim of providing feasible solutions to solve the problem of inappropriate information overload at the technological level, ranging from simple user-controlled information personalization to autonomous system-controlled adaptation.

Context-awareness is the second important issue of mobile and ubiquitous computing, because this type of computing requires sharing knowledge between individual environments and providing services that take the environmental characteristics and constraints into account. A human user is typically associated with many environments and consequently adopts different roles in each one; the system should then transparently recognize this role (Singh et al., 2006). The context itself can be defined as a piece of information that can be used to characterize the situation of a participant, so by sensing this context, applications can present contextual information to users or modify their behavior according to the environmental changes (Singh et al., 2006). A true ubiquitous system should provide the best possible service(s) based on the user role and its associated privileges, restrictions, location, and time. This requires a complete description of profiles and personalization of the resulting service. Profiles can be of the following types (El-Khatib et al., 2004):

- **User profile:** Personal properties and preferences.
- **Content profile:** Metadata about the content, including storage features, available variants, author and production, and usage (metadata is a topic addressed by Chapter VIII).
- **Context profile:** Dynamic information that is part of the context or status of the user, including physical, social, and organizational information.
- **Device profile:** Hardware and software characteristics of a computing device.
- **Network profile:** Resources and capabilities of the communication network.
- **Intermediaries profile:** Description of all adaptation services that intermediaries can provide.

Context-awareness and personalization are topics treated in Chapters I, III, IV, V, VI, VII, X, XI, and XIII of this book. Among the specific applications of context-awareness and personalization is collaborative filtering and recommendation, treated in Chapters II and III. Collaborative recommendation is a personalization technique that keeps track of user preferences and uses them to offer new suggestions in e-commerce or information access scenarios (O'Mahoney, Hurley, Kushmerick, & Silvestre, 2004). The idea is to recommend items to a target customer, by looking at customers who have expressed similar preferences. This helps individuals more effectively identify content of interest from a potentially overwhelming set of choices (Herlocker, Konstan, Terveen, & Riedl, 2004).

Some of the recent technologies on which personalized information services, context-awareness, and ubiquitous computing in general are grounded are: software components, service orientation, and multi-agent systems. A software component is any coherent design unit which may be packaged, sold, stored, assigned to a person or team (for development), maintained, and perhaps most importantly, reused (Meling, Montgomery, Ponnusamy, Wong, & Mehandjiska, 2000). Component-based development (or CBD for short) includes improvements in: quality, throughput, performance, reliability and interoperability, reducing development, documentation, maintenance, and staff training time and cost (Herzum & Sims, 2000; Szyperski, 2002). Most recent trends in software engineering show that future developments will follow in the CBD path. This argument is partially confirmed by the large amount of component development technologies that have existed for some years now (CORBA, EJB, DCOM, and .NET, among others), and also by the increasing amount of components available in the market (Andrews, Ghosh, & Choi, 2002). Services, and especially Web services, can be thought of as an evolution of the component notion (Apperly et al., 2003). By using interfaces and Web-enabled standards for discovery and representation, services (e.g., information services) are offered for consumption to different applications, making service consumption truly aligned with the possibilities of ubiquitous computing. In addition to components and services, software agents are another technology that can underlie mobile and ubiquitous computing. Agent technology is possible due to the convergence of artificial intelligence (which deals with autonomy and intelligence in agent behavior) and distributed object systems (which extend with mobility the object-oriented approach) (Marinescu, 2002). As such, an agent can be seen as a reactive program defined by autonomy (or agency), mobility, and intelligence (inference, planning, and learning capabilities). An agent can also be described in human-like terms of knowledge—knowledge of itself; knowledge of other agents, goals, or possible solutions; and knowledge of its own desires, commitments, and intentions—and capabilities (communication and reasoning) (Shakshuki, Ghenniwa, & Kamel, 2003). In this book, components and services related to context-awareness and personalization are treated in Chapters VI, VII, and XI. Agents are treated in several chapters, due to their prominence in modern software technology. In particular, Chapters III, XII, and XIII mention agent-based solutions to some of the challenges that will be presented in the next section of this preface.

## INFORMATION MANAGEMENT CHALLENGES

Mobility, ubiquitous computing, personalization, and context-awareness present a wide array of challenges related to telecommunication networks, device software, data management, and human and social issues related to this new form of exchanging information, collaborating, and consuming services. This book gives special attention to the challenges of information volume and overload, and to information heterogeneity. It also considers challenges with regards to information quality and dynamics, and to privacy in context-awareness. This is also linked to changing and uncertain information needs that add additional requirements to information service design.

As mentioned earlier, the volume of information carries with it issues of storage, distribution, and retrieval from the data management perspective, but also carries with it the possibility of information overload at the individual or group user level. This challenge is discussed in Chapters I, III, IV, VI, and VIII of this book, and in Chapter IX with special emphasis on image collections.

Another challenge already mentioned is that of information heterogeneity. Whether due to volume or not, heterogeneity implies a variety of data formats, sources, authors, languages, and other characteristics that determine the potential usage and interpretation of information. The use of standards, filters, translation templates, and other means may help in dealing with this issue. Chapters III, VI, and VIII consider it as part of their concerns.

Because of the volume and heterogeneity of information, in addition to a changing business environment and the changing nature of globally distributed information, information needs may also be unclear. If we add the existence of an ill-structured problem as motivation, then uncertainty (and changes) in information needs, and their associated queries, is another challenge to be considered. This is treated in Chapters VI and VIII of this book.

Besides volume, heterogeneity, and changing needs, there is another issue related to the quality of information. The trustworthiness, length, media format, digital resolution, or tractability of a piece of information are also important. Defining what quality of information is, what its attributes are, and how it should be included in the information-seeking and retrieval process is a challenge. Part of this challenge is addressed in Chapter VIII.

The last two challenges of interest for this book are information dynamics, treated in Chapter III, and privacy in context-aware solutions, the subject of Chapter VII. Information dynamics relates to the fact that information flows in a global and distributed environment, so it is far from being a static repository, and information seeking and retrieval should take this into account. It also means that information itself is subject to modifications, adaptations, additions, and revisions that make each information unit also independently dynamic. With regards to context-awareness, personalization and mobile or ubiquitous computing should take into account privacy as a very relevant requirement, which might conflict with the goals of context-aware services, but which can also be embedded into the service without compromising the identity, profile, or history of the users.

This book compiles several approaches to deal with the challenges just mentioned. This is the subject of the next section in this preface.

## TACKLING THE CHALLENGES

This book presents concepts, approaches, architectures, and models that contribute to dealing with the challenges of mobility and ubiquity. Personalized information retrieval and access is regarded as a remedy when it comes to relieving the problem of information overload. Many personalization algorithms

and techniques have emerged in different research directions, including user modeling, data mining, user profiling, context-aware computing, information visualization, and their combinations. Equipped with advanced personalization techniques and algorithms, many academic and commercial off-the-shelf information search services and tools are available to effectively filter out irrelevant information, and to rank and present information in a user-preferred way.

However, as shown earlier, dynamic and distributed environments challenge those personalized information search applications. Although the personalization techniques and algorithms are becoming mature, their centralized implementation is becoming less efficient to support the rapidly changing information needs taking place in dynamic and distributed environments. Changes in an organizational or a personal information need may lead to a need to redesign a complete application. Therefore, there is a requirement of designing personalized information retrieval and access in an agile and flexible way, which can be adapted easily to satisfy personalized organizational information needs with minimum effort.

This book presents approaches centered around service orientation, multi-agent systems, information retrieval and information filtering, in addition to intelligent techniques and ontologies to overcome some of these challenges.

Service orientation is taken as a design principle or underlying approach in Chapters VI, VII, X, and XI. Multi-agent systems are treated in Chapter XII from a role-based perspective to personalization; in Chapter III they are included in several of the examples provided; in Chapter XIII, a context model for multi-agent systems is provided. Information retrieval, from a content-based view, is treated in Chapter IX; from a personalization view, information retrieval is part of Chapters III and VI. Information filtering is also a part of the solutions. In Chapters II and III, filtering is discussed, giving special attention to collaborative filtering; context-aware filtering is the subject of Chapter VIII, and the issue of privacy is dealt with in Chapter VII. Three chapters address personalization in the specific context of the Web: Chapters IV and V treat personalization for Web data mining, and Chapter XI presents an approach for creating context-aware personalized Web services. A final approach treated in this book regards the role of ontologies; this is a subject treated in Chapters I and III.

This book agrees with Pierre (2001) in his statement that the delivery of information is the most powerful tool in building a knowledge-based economy. The convergence of solutions, like the ones presented in this book, can help improve the understanding of the new challenges of ubiquitous computing on top of those already existing in the already global, distributed information infrastructure of the Internet. By scaffolding this new paradigm of information access, exchange, and service provision and access, individuals and organizations will be able to harness the full potential of existing and emergent information technology, thus being a part of the construction and operation of the knowledge-based economy.

## ORGANIZATION OF THE BOOK

The book is organized into two sections. The first section includes five chapters with a primarily conceptual contribution which present some of the issues, definitions, and accounts of literature which provide a theoretical background for the rest of the book, and show issues and trends for research and practice. The chapters of this first part are briefly presented as follows.

Chapter I, “Learning Personalized Ontologies from Text: A Review on an Inherently Transdisciplinary Area,” presents the issue of information overload and personalized information retrieval and access (specifically for the Web) as a countermeasure. It views personalization as appropriately coupled to the Semantic Web, and thus ontology is at its foundation. The result proposed is to create personalized ontologies, which can be built through learning techniques. The authors review the methods, concepts,



and practices of learning personalized ontologies, and highlight contextual information extraction and personalized Web services as future trends in this area.

Chapter II, “Overview of Design Options for Neighborhood-Based Collaborative Filtering Systems,” focuses on collaborative filtering as a subtype of filtering systems (the other being cognitive filtering) and explores neighborhood-based techniques for this kind of filtering. The chapter provides an overview of different design options of neighborhood-based collaborative filtering systems, presented in line with the stages of collaborative filtering to highlight the design options relevant to the appropriate stage.

Chapter III, “Exploring Information Management Problems in the Domain of Critical Incidents,” presents an understanding of information management problems as divided into heterogeneity, overload, and dynamics. On the other hand, it presents computer-based solutions to deal with those information management problems: information discovery and retrieval, information filtering, information fusion, and information personalization. In addition to this review of problems and solutions, the chapter finally argues that exploring these issues in the domain of critical incident management helps cover the complexities of information management.

Chapter IV, “Mining for Web Personalization,” offers an introduction to information personalization, underlining the question of whether personalization is just hype or a real opportunity to deal with an increasing volume of information on the Web and the resulting information overload that comes with such a growing repository. By presenting Web mining as a method for Web information personalization, this chapter argues that personalization can be a real opportunity for the present and the future.

Chapter V, “Clustering Web Information Sources,” contributes an overview of clustering for improving personalization to support the area of Web data mining. It discusses personalization in the context of the growing Web and presents Web clustering as an approach to support personalization. It separates Web document clustering from user clustering, and then presents a literature survey of several approaches and algorithms to deal with these types of clustering, covering the processes and methods that are available and how they can be integrated.

The second section of the book consists of eight more chapters which present particular solutions (approaches, architectures, conceptual models, and prototypes) in the context of information personalization and its surrounding topics as presented in the beginning of this preface. A short description of these eight chapters follows.

Chapter VI, “A Conceptual Structure for Designing Personalized Information Seeking and Retrieval Systems in Data-Intensive Domains,” starts by highlighting information overload and heterogeneity issues, in addition to changing information needs. The problem is providing anywhere/anytime information access in data-intensive domains (e.g., crisis response). The proposed solution is situated in the context of mobility and software component and services. The chapter presents a conceptual structure which should act as a bridge between personalized information needs and implementation of information services.

Chapter VII, “Privacy Control Requirements for Context-Aware Mobile Services,” focuses on the privacy implications of context-awareness as a part of ubiquitous computing. The challenge is how to implement privacy requirements in context-aware services. The chapter presents a UMTS location-based mobile services testbed on a university campus in which a prototype is used to test the basic functionality of helping automate the process of getting user consent in acquiring context data.

Chapter VIII, “User and Context-Aware Quality Filters Based on Web Metadata Retrieval,” starts by presenting the volume of information on the Web as a challenge, resulting in information quality variability and uncertain information needs. By integrating the use of Web metadata and fuzzy theory into an ontology and architecture, the chapter proposes a user and context-aware quality filter. This filter is illustrated in an example of a query (in the economics domain).

Chapter IX, “Personalized Content-Based Image Retrieval,” reminds us of the growth of digital media (image collections in particular) in information networks and how this type of media cannot easily be described with text. Content-based retrieval uses image information, such as color, texture, and shape, but this results in a “semantic-similarity” challenge. This challenge is tackled in the chapter through the use of relevance feedback learning, and tested with the classic measures of precision and recall using a content-based image retrieval system that uses an image segment as query input.

Chapter X, “Service-Oriented Architectures for Context-Aware Information Retrieval and Access,” presents context as a natural part of human interaction, which, as described in the beginning of this Preface, is a fundamental aspect of mobility and ubiquitous computing. The chapter proposes the use of a service-oriented architecture to make use of different services along with context-aware action systems, exemplified with the implementation of a conference assistant system.

Chapter XI, “On Personalizing Web Services Using Context,” also combines services and context awareness. Focusing on Web services, this chapter contains an approach that divides context into three types: user context, Web service context, and resource context. Each of these contexts addresses user preferences, Web service composition, and computing resources, respectively.

Chapter XII, “Role-Based Multi-Agent Systems,” discusses the understanding of the notion of ‘roles’ from organization theory and its use as a modeling mechanism for multi-agent systems. As a result of the specification of roles, the E-CARGO (Environment, Classes, Agents, Roles, Groups, and Objects) environment is extended and presented as an architecture for role-based multi-agent systems that can provide a contribution to roles as preferences in a multi-agent-based personalization system.

Chapter XIII, “Towards a Context Definition for Multi-Agent Systems,” aims at redefining context for multi-agent systems. By presenting an object model for the notion of ‘context’, the authors contribute to an improvement in the understanding and use of this concept in the field of artificial intelligence. The model is applied to an example of an agent-based virtual environment of accident emergency rescue. Regarding the implications of integrating the concept of ‘context’ into the multi-agent systems, the latter can be better exploited in the context of personalization and context-aware information services.

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