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User-Generated Metadata in Social Software: An Analysis of Findability in Content Tagging and Recommender Systems

CAPSTONE REPORT

Michael Barnes
Manager, User Experience Design
VeriSign, Inc.

University of Oregon
Applied Information Management Program

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722 SW Second Avenue
Suite 230
Portland, OR 97204
(800) 824-2714

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Approved by

Dr. Linda F. Ettinger

Academic Director, AIM Program

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Abstract

for

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This study describes how user-generated metadata may be leveraged to enhance findability in web-based social software applications (Morville, 2005). Two interaction design systems, content tagging (Golder & Huberman, 2005) and recommender systems (Resnick & Varian, 1997), are examined to identify strengths and weaknesses along three findability factors: information classification, information retrieval and information discovery. Greater overall findability strength may be found in content tagging systems than in recommender systems.

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CHAPTER I. PURPOSE OF THE STUDY

BRIEF PURPOSE

The purpose of this study is to describe how explicitly collected and user-defined metadata may be used to enhance findability (Morville, 2005) in content tagging (Golder & Huberman, 2005) and recommender systems (Resnick & Varian, 1997) used in web-based social software applications (Morville and Rosenfeld, 2002). Findability is defined as the ability to locate desired information in web-based information systems through information classification, information retrieval, and information discovery methods (Morville, 2005). Content tagging and recommender systems are selected as the systems for evaluating the value of user-generated metadata due to their increasingly common role in social software design (Shneiderman, 2000).

Metadata is data that describes data (Tannenbaum, 2001 and Stephens, 2003). It defines specific characteristics of information-bearing entities to enhance their identification, discovery, assessment, and management (Durrell, 1985). For purposes of this study, user-generated metadata is defined as information that users are prompted to assign to a particular digital artifact such as a document, product, media file, or other content for the purpose of describing, categorizing, or rating for future retrieval (Mathes, 2004). Through web-based applications designed to capture user descriptions of content, the descriptive data may be used as metadata and manipulated to enhance the usefulness of the information system (Kimball, 1998). When this personal metadata is shared and exposed to other users of an information system as a design strategy to aid information retrieval and discovery (Morville and Rosenfeld, 2002), the value of the metadata evolves to provide both a personal and social benefit (Mathes, 2004).

Social software supports, extends, and derives its value from social behavior (Coates, 2005). The active participation of users in the process of information creation, classification, and discovery (Mathes, 2004) is a core characteristic of social software and social computing (Millen and Patterson, 2002). As such, the creation of user-generated metadata may be considered a collaborative and social activity when it is designed to support findability (Morville, 2005) for all users of an information system. This is the goal of most content tagging and recommender systems (Bielenberg & Zacher, 2005). In the search and content management fields, there is growing interest in content tagging tools that enable users to assign their own descriptive metadata to content using web-based tools so that information may be intuitively cataloged and more easily retrieved (Mathes, 2004). Similarly, recommender systems rely on a combination of user preferences and the collective ratings of items to produce relevant information (Resnick & Varian, 1997).

The study is designed as a literature review and is exploratory, interpretive, descriptive, and qualitative (Leedy & Ormrod, 2005). Literature collection is limited to existing literature screened as part of a conceptual content analysis approach. Once sub-topics and delimitations are clearly defined and a research map finalized, a systematic search for relevant and meaningful literature related to predefined topics is conducted.

A conceptual content analysis method (Palmquist, et al., 2006) is employed to identify strength and weakness elements related to three findability factors (information classification, retrieval, and discovery) as found in content tagging and recommender systems. This approach is appropriate to meet the goals and purpose of this study because it enables the collection and review of content related to predefined topical areas. Results of the content analysis process are presented in a series of six tables that display the strengths and weaknesses of the three search related factors – information classification, retrieval, and discovery – for each of the two social software systems selected for the study – content tagging and recommender systems. The strength and weakness elements of each factor are determined by their ability to enhance findability in content tagging and recommender systems.

The primary outcome of this study is a reference resource presented as a comparative tool (see Table 10: Strengths, Weaknesses, and Examples of Content tagging and Recommender Systems). The tool is produced for user experience practitioners who design or are considering designing web-based social software applications that leverage user-generated metadata to enhance findability. Specific findability strengths, weaknesses, and application examples of content tagging and recommender systems are identified. This list will help user experience professionals assess the reported findability value of each system in classifying, retrieving, and discovering information.

Full Purpose

There is value in information (Baily, 1997), but finding valuable information online is difficult due to the growing volume of data, diversity of file formats, and constantly changing nature of the medium (Morville, 2005). In an information-driven economy, contextually relevant information becomes an asset and form of currency (Bailey, 1997) that is critical for business success (Marks, 2006). However, information is becoming both more abundant and more difficult to locate at once (Limbach, 2006). For most organizations and consumers, quick access to relevant information has simultaneously become more important and challenging due to the increased amount of unclassified information and the lack of adequate tools to capture and organize information (Morville, 2005). The exponential growth of information on the Web each year makes it difficult to adequately separate irrelevant data from potentially useful information (Barbasi, 2003). The abundance of information sources, choices, and resulting questions of credibility and authority can cause information seekers to become overwhelmed, fatigued, and even depressed (Schwartz, 2005). In his book "Technopoly," Postman (1993) argues that the information overload facilitated by information technology is so pervasive that it is rapidly diminishing social institutions, values, and traditions due to the cognitive demands of keeping pace with the incessant flow of data and understanding its relevance to everyday life.

Since the advent of the web log in 1997, there have been a growing number of web-based software tools that leverage the active participation and contribution of users through the solicitation of user-generated content to create community-centric information systems (Tepper, 2003). These tools have been designed to facilitate a socially-oriented and participatory user experience to encourage users to contribute, connect, and communicate with each other (Mathes, 2004 and Morville, 2005). Social software applications typically employ overt methods of capturing user-generated metadata as is the case with content tagging and recommender systems (Tepper, 2003). Social software technologies (Bielenberg & Zacher, 2005) are designed to encourage users to provide descriptive, associative, evaluative, or preferential data to informational artifacts (Golder & Huberman, 2005). Social software provides tools that allow people to come together and find each other's ideas, circulate new and compelling content, and inspire online collaboration, cooperation, and conversation (Tepper, 2003).

User-generated metadata may be used to enhance information retrieval and discovery (Mathes, 2004) in web-based information systems (Morville, 2002) such as social software applications (Bielenberg & Zacher, 2005). According to Dye (2006), social software applications that leverage content tagging tools (such as folksonomies) present tag terms in formats that allow users to view their own tag patterns and manage their personal tag collection in ways that make their content retrieval more intuitive and rewarding.

> "In most enterprises content is categorized by a handful of users who dictate a fixed hierarchical taxonomy for the broader audience. In the world of Web 2.0, every user will be able to label or "tag" content in a way that is personally meaningful—collaboratively and implicitly generating a classification of content purely by these actions. This is commonly known as a "folksonomy." Self-service labeling ultimately improves the ability of users to find meaningful content and offers an alternative way for them to discover useful information" (BEA, 2006, p.30).

The purpose of this study is to identify findability strengths and weaknesses in the information classification, retrieval, and discovery capabilities of content tagging and recommender systems that leverage user-generated metadata. This study focuses on less formal methods of creating of metadata that do not require the infrastructure, cost, or expertise of formal taxonomies or content management applications (Boyd, Davis, Marlow, & Naaman, 2006). It is a more organic form of information classification that relies on the participation the users of the system rather than on professional taxonomists or metadata specialists. This design of collaborative taxonomy creation through content tagging is often referred to as a "folksonomy" - a portmanteau that combines the words folks and taxonomy (Dye, 2006). This study is focused on tools that enable participatory metadata production where users of information create metadata for their own individual use that is also shared throughout a community of other users that benefits from this group classification process (Mathes, 2004). Emphasis is on defining how unstructured user-generated metadata in two selected types of information systems – content tagging and recommender systems - may be leveraged to improve the shortcomings of traditional metadata design and information management strategies.

For purposes of this study, findability refers to the likelihood of retrieving desired information in a web-based system. Findability is simply the quality of being locatable or navigable (Morville, 2005). At the item level, we can evaluate to what degree a particular object is easy to discover or locate. At the system level, we can analyze how well a physical or digital environment supports navigation and retrieval. Information that is highly findable is easily located and accessed through the use of a well developed information retrieval system (Morville, 2005).

Information Classification may be defined as the process of grouping information into intuitive categories by applying descriptive metadata that may be used as part of an organization schema designed to aid information retrieval and discovery (Mathes, 2004). Information Retrieval is defined as the process of locating desired information through the use of web based search utilities

(Morville, 2004). Information Discovery may be defined as the process of retrieving useful information through serendipitous means (Morville and Rosenfeld, 2002).

A web-based information system consists of informational sub-systems (organization, labeling, navigation, and searching) that help people find and manage information more successfully (Morville & Rosenfeld, 2002). Explicitly collected and user-generated metadata is information captured from the users of an information system through overt, permission-based methods (Mathes, 2004) that define or describe the content of the system (Morville, 2005). The user experience of web-based applications can be designed so that metadata can be created, viewed, and modified by system users to assist in defining and locating artifacts in an information system (Kimball, 1998).

A web-based recommender system is defined as an information system that captures implicit and explicit user decisions and behavior in order to recommend content that matches previous choices (Resnick & Varian, 1997). This study focuses on explicit user-generated actions such as content rating/ranking that provide personal metadata about the item being acted upon. Most recommender systems rely on collaborative filtering software and algorithmic models to generate predictive recommendations. Recommender systems use the opinions of a community of users to help individuals in that community more effectively identify content of interest from a potentially overwhelming set of choices (Resnick & Varian, 1997). Recommender systems typically rely on user inputs such as content rankings/ratings and reputation scores which serve as metadata for collaborative filtering technology designed to produce meaningful recommendations based on personal preferences (Resnick & Varian, 1997). Recommender systems capture people’s opinions and preferences about items in an information domain in order to recommended new, novel, and unexpected items that the user is predicted to want (Cosley et al., 2003). Many consumer and collaboration-based web applications employ recommender system functionality that attempts to predict information that a user may be interested in based on any number of complex collaborative filtering algorithms (Schafer, Konstan & Riedl, 2001). Most often, recommender systems attempt to provide users with new product ideas or topics based on their previous selections or from a set of pre-existing user-ranked choices (Basu, Hirsh, & Cohen, 1998). Recommender systems typically collect information in two ways: through user-initiated pre-ranking methods, or a by employing more implicit, covert behavior monitoring techniques that generate recommendations based on measured purchase histories, page and product view time, or by connecting common items associated with a specific item that has received a favorable ranking (Katz, Selman, & Shah, 1997). Ultimately, recommender system technologies compare related data elements to generate new recommendations (Pine and Gilmore, 1999).

A web-based content tagging system is defined as an information system that enables users to assign uncontrolled keywords to digital information artifacts (Macgregor and McCulloch, 2006). Such tags are used to enable the organization of information for personal access and organization purposes (Mathes, 2004). When tags are shared, they allow the browsing and searching of tags attached to information resources by other users thus providing a social benefit (Macgregor and McCulloch, 2006).

The larger method of this study is a literature review (Leedy & Ormrod, 2001) in which literature is collected, evaluated, and analyzed using a qualitative content analysis methodology (Palmquist, et al., 2007). Because of the recent emergence of web-based social software applications that capture user-generated metadata, the literature collection examines 60 sources published between 1989 and 2007. The primary literature search is focused on the following terms: user-generated metadata, social software, content tagging, and recommender systems. The search is conducted in academic and professional journals, industry-specific periodicals, and texts as defined in the Methods section of this study. Thought-leader web sites and web logs (blogs) are read to locate related citations or references that lead to legitimate, peer reviewed research literature.

Selected literature is analyzed using a conceptual content analysis strategy, as described by the Colorado State University Writing Lab: “In conceptual analysis, a concept is chosen for examination, and the analysis involves quantifying and tallying its presence” (2006). Conceptual analysis is conducted to evaluate two user-generated metadata systems - content tagging and recommender systems - in order to describe how they facilitate information classification, retrieval, and discovery in web-based social software applications. The goal of the conceptual analysis is to identify examples of user-generated metadata used in social software contexts in order identify their relative strengths and weaknesses in relation to user search and findability needs. The focus of the analysis is on three findability factors as they appear in content tagging and recommender systems – information classification, retrieval, and discovery. Elements related to any one of these three factors, are identified, recorded and defined as strength or a weakness based on their ability to enhance information findability (Morville, 2004). The specific coding process is defined in the Methods chapter, under Data Collection and Analysis.

The result of the content analysis process is the identification of key strength and weakness elements for three findability factors (classification, retrieval, and discovery) in two social software systems (content tagging and recommender systems) that leverage user-generated metadata. Strengths and weaknesses of each factor are defined by their ability to provide relevant and expected information to users. The results are presented in six tables. Each table captures the strengths and weaknesses of one of the three factors when present in one of the two interaction systems.

The primary outcome is a comparative tool (table 10) designed to help user experience and interaction design professionals build web-based social software applications that leverage user-generated metadata to enhance findability. The table is formatted to present criteria to assist user experience practitioners tasked to design web-based social software applications that leverage user-generated metadata to enhance findability (Morville, 2004). The tool may be quickly and easily scanned to provide practitioners with a reference matrix as they consider how to approach their work. In particular, specific strengths, weaknesses, and applications of content tagging and recommender systems are identified to create a list of factors that help determine the reported value of each system in classifying, retrieving, and discovering information.

For purposes of this study, user experience professionals are the personnel responsible for creating a visual information system that forges the business, content, and user needs of web-based projects to ensure that the target audience is able to complete intended tasks with minimal confusion, barriers, or interactive challenges (Morville and Rosenfeld, 2002). They are often required to work on the graphic design, information design, and technology components of web development projects (Morville & Rosenfeld, 2002). Through the integrative design of search systems, navigation schemes, and interaction models that create a larger information ecosystem, user experience professionals create the structural and interactive architecture of social software applications (Morville, 2004). These professionals carry titles such as information architect, interaction designer, human-factors engineer, and usability analyst (IAI, 2006). A comprehensive definition of this profession is provided by the Design Council (2006), a non-profit professional organization designed to foster awareness of interactive design disciplines:

> "Interaction design is the key skill used in creating an interface through which information technology can be manipulated. As products and services are increasingly being created using information technology, interaction design is likely to become the key design skill of this century. It focuses on users attempting to complete a task or achieve an objective, using a tool (device) in a particular context. Interaction is the influence of persons or things on each other, encompassing action and communication. In the context of digital and networked products and environments, people influence a system to achieve a purpose, and feedback is supplied by the system to the user as to their success, and the new state of the system. Interaction design considers human cognition and emotion, context of use, task analysis, user experience and learnability, understanding of functions, error feedback and failure recovery." (p.1)

In this study, content tagging and recommender systems are selected as models of web-based information systems that leverage user-generated metadata. The level of analysis is at a general, systems-based level and is not intended to evaluate specific tools or applications by name. Instead, this systems approach represents many possible tools and applications that employ content tagging or recommender functionality as methods of soliciting user-generated metadata to aid findability. Therefore, in this study, the term "system" refers to a general group of web-based applications that utilize content tagging or recommender system methods.

For each of the two general systems identified (content tagging and recommender systems), three specific findability factors are evaluated to determine how user-generated metadata may enhance findability. The three findability factors are information classification, information retrieval and information discovery. Therefore, the term "factor" refers to any of these three findability factors.

The two systems and three factors are then combined to create six “system-factor” combinations that are used to structure the literature selection and content analysis process. The system-factor combinations also represent the structure used to present the study’s results and outcomes. Therefore, the term “system-factor” refers to any of the following six system and factor combinations:

- Content Tagging Systems and Information Classification (CT-IC)
- Content Tagging Systems and Information Retrieval (CT-IR)
- Content Tagging Systems and Information Discovery (CT-ID)
- Recommender Systems and Information Classification (RS-IC)
- Recommender Systems and Information Retrieval (RS-IR)
- Recommender Systems and Information Discovery (RS-ID)

For each of the six system-factor combinations, specific strength and weakness elements are identified from the literature to determine findability strengths and weaknesses across combinations. Therefore, the term “element” refers to a specific findability strength or weakness associated with a particular system-factor combination. These system-factor-element patterns will be described and explored in more detail in the Data Analysis and Conclusion sections.

SIGNIFICANCE OF THE STUDY

The Internet is the newest medium for information, the fastest growing information source of all time, and the information resource of first resort by its users (Lyman and Varian 2003). The world's total yearly production of print, film, optical, and magnetic content would require roughly 1.5 billion gigabytes of storage - equivalent of 250 megabytes per person for each man, woman, and child on earth (Lyman and Varian 2003).

According to Nielsen/NetRatings (2006), there is a worldwide Internet population of over 600 million internet users. The average user in the United States spends more than 34 hours online at home each month and over 88 hours per month at work (Neilsen/Netratings, 2006). The typical American consumer now generates some 100 gigabytes of data during his or her lifetime, including medical, educational, insurance, and credit-history data. When this figure is multiplied by 100 million consumers, the result is 10,000 petabytes of data per American (Whiting, 2002). Additionally, the number of measurable, indexed web pages exceeds 11.5 billion pages or more per month (Gulli and Signorini, 2005) with 213 million searches per day in the US alone (Sullivan, 2006).

Over ten years ago, Varian (1995) stated “Information has always been a notoriously difficult commodity to deal with, and, in some ways, computers and high-speed networks make the problems of buying, selling, and distributing information goods worse rather than better.” Today, information is not only becoming more frequent and available in more formats, but is also becoming more ubiquitous and accessible through multiple mediums such as the internet, email, cell phones, and portable media devices that receive information through wireless networks (Morville, 2005). New information classification, retrieval, and discovery tools are needed to aid findability (Morville, 2005). This study examines two such tools – content tagging and recommender systems – that rely on user-generated metadata to improve information classification, retrieval, and discovery. A December 2006 survey by the Pew Internet & American Life Project has found that 28% of internet users have tagged or categorized content online such as photos, news stories, or blog posts. On a typical day online, 7% of internet users say they tag or categorize online content (Rainie, 2007).

Social navigation applications typically employ overt methods of capturing user-generated metadata such as content tagging (Fu, et al., 2006), and ranking systems. Social software technologies (Bielenberg & Zacher, 2005) are designed to encourage users to provide descriptive, associative, evaluative, or preferential data to describe digital informational artifacts (Golder & Huberman, 2005). By providing tools that allow people to come together to contribute and retrieve content, ideas may circulate more rapidly, which in turn will bring even more collaboration, cooperation, and conversation online (Tepper, 2003). In the search and content management fields, there is growing interest in content tagging tools that enable users to assign their own descriptive metadata to web-delivered content so that it may be quickly and intuitively classified, cataloged, and retrieved (Mathes, 2004). Tagging is gaining prominence in part because it advances and personalizes online searching. Tagging is a kind of next-stage search phenomenon – a way to mark, store, and then retrieve the web content that users already found valuable and want to track (Rainie, 2007).

While there has been significant growth in the number and diversity of web-based social software applications generally and applications that attempt to capture user-generated content specifically (Tepper, 2003), this researcher finds little research that addresses the way user-generated metadata is being used to improve information classification, retrieval, and discovery. Several authors have documented their opinions on collaborative tagging but few have done so via the scholarly literature (Macgregor and McCulloch, 2006). Despite a considerable amount of attention received in professional circles, as represented in various blog posts and conference papers, little academic research work has been invested in tagging systems to date (Marlow, et al., 2006). Additionally, a search for research defining user experience design considerations that could support or diminish the success of information systems that leverage user-generated metadata reveals that such information is not in abundance. There is clearly much research to be done in this field in order to quantify the value of user-generated metadata and its ability to enhance findability in content tagging and recommender systems. While not qualitative or comprehensive enough to contribute to the more complex research needed to measure effectiveness, a goal of this study is that the outcome provides a significant applied benefit to user experience practitioners. It provides an analysis of an emerging information retrieval paradigm that is dramatically different than existing information retrieval tools (Mathes, 2004). This information is significant to user experience designers tasked to design social software applications that leverage user-generated metadata to achieve the intended outcomes of the application.

LIMITATIONS TO THE RESEARCH

This study is limited by time, content, and scope.

Time

The literature search focuses on work completed within the past ten years (1997 - 2007). Work completed more than ten years ago was dismissed unless it represented "timeless" foundational work of historical significance related to topics of social computing, metadata creation, web navigation, information systems, or information classification. Literature was deemed timeless if it appeared frequently in the citations of contemporary works and used to establish foundational background context.

Content

Works that are directly related to one or more of the study's key words are retained for reference. Key words are presented in Figure 1 below. Additional supporting content is collected if it provides foundational background or context that supports the study's key words and purpose.

Scope

This study focuses on three specific uses of user-generated metadata - enhancing information classification, retrieval, and discovery – when deployed in two types of web-based information systems - content tagging and recommender systems. Emphasis is on explicitly collected and user-defined metadata only. Implicit aspects are ignored in this study, as one way to control scope. Technical topics related to the algorithmic design and deployment of metadata systems, collaborative filtering, or other technology-driven approaches to classify or retrieve information were not pursued or retained.

While this study identifies information design, as an element of a holistic information search system, it does not provide an analysis of or recommendations for the ways information systems could be visually designed or presented. Similarly, this study does not evaluate factors related to the usability of web-based information systems, and it is not a usability analysis of specific social computing applications, tools, or services.

It is not the intent of this study to measure or otherwise quantify the effectiveness of user-generated metadata systems. Rather, the study seeks to provide results based on a literature review using qualitative methods.

While social networking and social computing systems are referenced, it is not the intent of this study to provide an analysis of social network theory or its key structural elements such as strong and weak ties, centrality, or clustering.

Details of W3C and the Dublin Core Metadata Initiatives are referenced for context, but are not an intended focus of the work. Only user-generated metadata is evaluated as a general concept. Specific metadata types such as administrative, descriptive, or structural are not evaluated or indented to be a factor of the analysis.

This study makes reference to taxonomies and controlled vocabularies as a comparative device for describing strength and weakness elements of content tagging systems. However, it is not the intent of this study to analyze the effectiveness of taxonomies or areas related to controlled vocabularies such as thesauri, ontologies, authority files, facets, and synonym rings.

Problem Area

In response to the ever-increasing growth of information creation and distribution, content management and classification technologies have been developed to help identify, retrieve, and manage useful information (Melville, 2004). These tools typically employ metadata that are mapped to a controlled vocabulary or taxonomy designed to classify information and make it easier to retrieve through a limited and specific set of search terms (Garshol, 2004). Taxonomies, thesauri, ontologies, facets, and synonym rings are components of formal, structured classification systems designed to make information easier to classify and retrieve (Morville & Rosenfeld, 2002). The common ingredient that ties these components together is metadata.

Metadata is structured data which describes the characteristics of an informational artifact and typically consists of a number of pre-defined elements representing specific descriptive attributes such as title, creator, abstract and keywords (Taylor, 2003). Metadata provides a mechanism for organizing information in order to make it easier to locate and retrieve (Mathes, 2004). It may also be administrative in nature and define more structural aspects such as creation date, when and how it was created, file type and other technical information, digital rights, and who can access it (Morville & Rosenfeld, 2002).

Metadata may be directly embedded in digital objects or stored separately in a database used to assign metadata to information artifacts based on predefined rules such as controlled vocabularies and taxonomies (NISO, 2004). It may be machine generated or manually defined. Metadata schema are sets of metadata elements applied to a group of information artifacts (such as books in a library) designed to provide meaning for specific purposes, and consist of unique data fields which combine to define the semantics of the scheme (NISO, 2004).

When metadata is organized into systematic groupings used to define and structure information, it becomes taxonomy - a subject-based classification that arranges the terms in the controlled vocabulary into a hierarchy (Garshol, 2004). When deployed in web-based systems, the goal of a taxonomy is to name and classify digital artifacts in order to place them in intuitive categories that can suggest familial relationships and meaningful associations (Barnwell, 2005). The benefit of this approach is that it allows related terms to be grouped together and categorized in ways that make it easier to find the correct term to use whether for searching purposes or to describe an object (Garshol, 2004).

Metadata and taxonomies are typically created by professionals tasked to administer content management tools or by individual authors of various content artifacts. For example, in libraries and other large organizations with significant amounts of information, creating metadata has "traditionally been the domain of dedicated professionals working with complex, detailed rule sets and vocabularies" (Mathes, 2004).

The movement towards attaching author-created metadata to documents was championed by key information organizations such as the World Wide Web Consortium (W3C) and the Dublin Core Metadata Initiative whose goal it is to "promote the widespread adoption of interoperable metadata standards and develop specialized metadata vocabularies for describing resources that enable more intelligent information discovery systems" (DCMI, 2006).

While both author and professional metadata management initiatives help to organize an ever-increasing amount of electronic information, both approaches have their limitations. Author-created metadata is less controlled and often yields inadequate or inaccurate descriptions of the information it is intended to classify (Mathes, 2004). The primary problems with professional taxonomy management at the system level is scalability and its impracticality for the vast amounts of content being produced and used, especially on the World Wide Web (Mathes, 2004). Taxonomy management is also time and resource consuming. "Taxonomy building needs to be targeted and strategic. Maintaining taxonomy is an oft-overlooked requirement and an underestimated cost (Conway and Sligar, 2002)." The apparatus and tools built around professional cataloging systems are generally too complicated for anyone without specialized training and knowledge.

Search and content management software provide highly structured methods of information classification and location (Conway & Sligar, 2002). These tools are often algorithmically designed to produce relevant search results (NISO, 2004) or to apply formal taxonomies and controlled vocabularies to aid information categorization and retrieval (Morville, 2005). However, they lack overt human participation in the process of labeling, storing, or retrieving information (Mathes, 2004). While automated, structural, and mathematical models exist to help users locate information, they lack the immediate, overt, and interactive participation of the user (Sturtz, 2004). Instead, they rely on expert classifiers and formal rules to define and retrieve information that cannot quickly accommodate the real-time organic evolution and complex semantic variations of language (Mathes, 2004). Users need an additional tool to aid in information retrieval – one that accommodates individual, group, and community-level descriptors in order to provide an additional level of information definition and categorization (Golder & Huberman, 2005). Information systems that leverage user-generated metadata, as the two systems presented in this study (content tagging and recommender systems) may enhance automated tools that rely solely on algorithms or controlled vocabularies because they incorporate real-time user and community feedback to shape the classification and context of information tools for retrieving and discovering information (LaMonica, 2006).

CHAPTER II. REVIEW OF REFERENCES

The Review of References section provides brief descriptions of the key literature selected for this study. The references included in this section were selected based on their importance to the study's foundation, frame, and focus. They are considered instrumental in supporting the study's purpose of describing how explicitly collected and user-defined metadata may be used to enable information classification, retrieval, and discovery in content tagging and recommender systems. The key sources selected for this review meet one or more of the following criteria:

1) They are used significantly as methodology references
2) They provide larger contextual references that help build the study's foundation
3) They are part of the data set selected for coding during the content analysis process

Each review is intended to define the value and relevance of the reference in relation to the study's purpose, and includes its primary contributions to the study and the criteria used to establish its credibility. As such, each review addresses the following criteria:

1) A summary of the information deemed important to the study's purpose.
2) The section(s) of the study that the reference supports (i.e. purpose, problem statement, significance, key definition, etc.) and/or if the reference was reviewed as part of the data analysis.
3) A description of the source's origin, author(s), and academic credibility.

The reviews presented in this chapter are grouped in sub-sections according to the following content areas:

1) Literature describing the role of user-generated metadata in content tagging systems
2) Literature describing the role of user-generated metadata in recommender systems
3) Literature describing information classification, retrieval, and discovery
4) Literature Supporting Research Methodologies

Reviews are presented in alphabetical order in each sub-section.

Literature Describing the Role of User-Generated Metadata in Content Tagging Systems

Dye, J. (2006). Folksonomy: A game of high-tech (and high stakes) tag. *Econtent Magazine*. April. 38-43.

Dye provides a comprehensive introduction to folksonomies and the role of user-generated metadata in facilitating information classification, retrieval, and discovery in web-based search systems. He provides an overview of the key goals of folksonomies which rely on user-created content tagging - a key factor of this study.

Dye also provides distinctions between broad and narrow folksonomies to further define their value and utility in specific informational contexts. Broad – or public - folksonomies are created when multiple users assign tags to the same content, essentially creating personal metadata that is aggregated with other tags and made publicly searchable. Users of broad folksonomies see what other tags have been created for certain content and use this information to broaden their understanding of the content they are seeking. They're often referred to as social classifications, since seeing what other terms users have used to classify content supports serendipitous information discovery. It provides a bottom-up form of user defined taxonomy rather than a top-down controlled vocabulary set as part of a traditional taxonomy design.

"Collaboration through collective tagging gives members of these communities a chance to build their own search systems from the ground up, based on their own vocabularies, interests, and ideas. Folksonomy sites use simple popularity (number of tags) to rank articles on their homepages, so users can easily sample what the rest of the community has been tagging" (Dye, p. 40).

Narrow – or personal - folksonomies, are designed to benefit the individual more than the group by allowing users to tag their own content so that they can easily retrieve it and help others find it. Although narrow folksonomies lack the aggregation into formal search systems and the social cohesion of broad folksonomies which lead to improved search systems, they are useful for assigning personal metadata to certain content types that would otherwise be missed by automated search tools such as multimedia files which contain no text for scripts to interpret.

This reference is used to support the study's description of content tagging and folksonomy systems, and it is referenced primarily in the Purpose and Problem Statement sections of this study.

This article has been cited by 2 other sources (via Google Scholar; retrieved January 2, 2007). Jessica Dye is an Illinois-based journalist who writes on topics related to ecommerce, digital content, and technology. She has published three articles through eContent Magazine which is a business-centric online resource that provides applied research, reporting, and analysis of electronic content related issues. It is written for executives, professionals, and researchers involved in content creation, management, and distribution in both commercial and enterprise environments. From the econtentmag.com website: "The magazine has a mission to clearly identify and explain emerging digital content trends, strategies, and resources that will help readers navigate the content maze and find a clear path to profits and improved business processes.”

Golder, S, A. & Huberman, B, A. (2005). The structure of collaborative tagging systems. *Information Dynamics Lab: HP Labs*, Palo Alto, USA, available at: http://www.hpl.hp.com/research/idl/papers/tags/tags.pdf

This is a key reference for understanding the structure and components of collaborative tagging systems that rely on user-generated metadata for the classification and retrieval of web-based content. For purposes of this study, it is used as a primer on the topics of information classification, retrieval, and discovery in content tagging systems. This reference is used to support the study’s purpose and problem statement, and is used as part of the data set selected for coding during the content analysis process.

In this paper, Golder and Huberman analyze the structure of collaborative tagging systems as well as their user-interaction components. They outline patterns in user activity, document frequencies of outcomes, and the general categories of tags that typically evolve in content tagging systems. Of particular value to this study, they document the stability in the relative proportions of tags within a given content item (url for purposes of the study). Finally, the authors present a collaborative tagging model that predicts how these stable patterns emerge and discuss their importance to the development and distribution of shared knowledge.

A key outcome of this study is that tag/term patterns tend to become consistent – or stabilize – over time. The fact that any user may tag a piece of content with any term they desire, introduces significant ambiguity into the information system. Nevertheless, because stable patterns do eventually emerge in large collective tag patterns, minority opinions can coexist alongside extremely popular ones without disrupting the nearly stable consensus choices made by most users. Golder and Huberman also conclude that information tagged by others is only useful to the extent that the users in question can make sense of the content in the same contextual way.

This paper has been cited by 53 other sources (via Google Scholar; retrieved January 2, 2007). Scott Golder has published 7 papers related to collaborative tagging. He is a member of the Information Dynamics Lab at Hewlett Packard Laboratories (the central research lab for Hewlett-Packard), and his research is focused on social information organization and social sharing of media content. Bernardo Huberman is a Senior HP Fellow and Director of the Information Dynamics Lab at Hewlett Packard Laboratories, and he is a Consulting Professor at Stanford University. He has published over 150 papers related to information on the World Wide Web, with particular emphasis on the dynamics of information growth and use.

Mathes, A. (2004). Folksonomies - cooperative classification and communication through shared metadata [electronic version]. Paper written for LIS590CMC - Computer Mediated Communication - as part of the Master of Science program at the University of Illinois at Urbana-Champaign. http://www.adammathes.com/academic/computer-mediated communication/folksonomies.html

Mathes' paper provides a comprehensive introduction to cooperative classification through user-generated metadata, and is a key source for content tagging and "folksonomy" related references as used throughout this study. He outlines a set of benefits and shortcomings of user-generated metadata in web-based content classification systems.

This paper is relevant to the current study as it examines user-generated metadata as applied in web-based search systems. In particular, it examines the benefits and weaknesses of user-generated metadata used to improve information retrieval in web-based searched systems. The paper focuses specifically on user-created metadata, "where users of the documents and media create metadata for their own individual use that is also shared throughout a community."

The following concepts are identified during coding (as part of content analysis) as key contributions of this paper:

A set of limitations/weaknesses of content tagging/folksonomies:

- Tag/term ambiguity (no structure or control; multiple term meanings)
- Use of spaces, acronyms, personal notes, and multiple words in tags
- Lack of synonym control

A set of capabilities/strengths of content tagging/folksonomies:

- Enhances browsing and serendipitous search
- Establishes desire lines(new pathways to information), accommodates organic vocabulary changes, and supports unique user vocabulary/specialized terminology/jargon
- Low barrier to Entry, low cognitive/learning costs
- Feedback - tight feedback loop (see results of tagging immediately)
- Individual incentives - self organization
- Collective benefit – tags support findability for all

This reference is used to support the study's purpose, significance, and problem statement sections. It is also used as part of the data set selected for coding during the content analysis process.

This paper has been cited by 61 other sources (via Google Scholar; retrieved January 2, 2007). Adam Mathes has written 10 papers related to computer mediated communication, ontological classification, and information retrieval. He holds a master of science degree in Library and Information Sciences from the University of Illinois at Urbana-Champaign and a bachelor of science degree in computer science from Stanford University. This paper was written as part of the course requirement for Computer Mediated Communication - LIS590CMC - at the University of Illinois. The paper is frequently cited by subject matter experts and in web communities dedicated to the discussion of user-generated metadata and content tagging (folksonomies). Mathes is the co-creator of Consumating.com – a web-based social networking application acquired by c|net Networks (cnetnetworks.com) that leverages user-generated metadata (profiles) to locate others with common interests.

Tepper, M. (2003). The rise of social software. *netWorker Magazine Online*. Volume 7, Issue 3. 18-23

This article provides a cogent definition of social software, and includes examples of social software applications that help frame a key component of this study – web-based social software applications. This source provides a part of the definition for social software as used in this study and presented in the Definitions section the study.

In this article, Tepper emphasizes the collaborative communication design inherent in social software. He defines social software as "various, loosely connected types of applications that allow individuals to communicate with one another, and to track discussions across the Web as they happen" (Tepper, p.19). Tepper outlines the critical information and communications feedback loop inherent in social networking applications that leverage user-generated metadata. "By building tools that allow people to come together and find each other's ideas, it makes it easier for new ideas and new tools to circulate, which in turn will bring even more collaboration, cooperation, and conversation online" (Tepper, p.23).

This article has been cited by 8 other sources (via Google Scholar; retrieved January 2, 2007). Tepper has published five articles on topics related to social software and web-based social networking. At the time of publication, Tepper was a contributing editor and contributor at NetWorker Magazine - published by ACM since 1997. NetWorker Magazine is a not-for-profit educational association serving those who work, teach, and learn in the various computing-related fields.

Literature Describing the Role of User-Generated Metadata in Recommender Systems

Schafer, J. B., Konstan, J., & Reidl, J. (2001). E-Commerce recommendation applications. *Data Mining and Knowledge Discovery*, 5. 115–153.

The article defines common recommender system methods, strategies, and user interaction models. An important outcome of this study is a reference chart (defined as a taxonomic table) for viewing recommender system strategies, methods and information exchange practices found in many well-known and commonly used web sites that employ a recommender system (in 2001). The taxonomy identifies the inputs required from the consumers, the additional knowledge required from the database, the ways the recommendations are presented to consumers, the technologies used to create the recommendations, and the level of personalization of the recommendations. Additionally, five common recommender system ecommerce application models are presented, defined, and evaluated.

Another key aspect of this study is that Schafer, Konstan, and Reidl provide a foundational assessment of existing recommender system strategies highlighting common functional components and best practices. This article provides the foundational breadth needed to understand the strengths and weaknesses of various recommender system designs as defined by their ability to classify content in contextually meaningful formats in order to present useful recommendation results to uses of ecommerce sites. In most cases this information is presented in the context of recommender strategies designed to support information discovery that is useful for up and cross-selling opportunities.

Frequently referenced sections from this paper that are used in the current study include the assessment of data input/output strategies (p. 10), recommender system methods (p. 12), design issues (p. 13), and recommender application models (p. 14). The taxonomy graph (table 1, p. 23) provides a visual representation of the various recommender strategies and their unique applications relative to each other.

The final result of the paper – a taxonomy grid of various recommender systems, their strengths, and their operational designs – makes this a helpful reference when examining the topic of recommender systems in general and the topics of this study in particular. This reference is used to support the study's purpose and significance, and it is also used as part of the data set selected for coding during the content analysis process.

This article has been cited by 246 other sources (via Google Scholar; retrieved January 2, 2007). The authors are contributing researchers for the University of Minnesota's GroupLens Project (http://www.grouplens.org/) which consists of faculty researchers from the Department of Computer Science and Engineering focused on research related to recommender systems, collaborative filtering, and online communities. Since 1994, the Group Lens Project has yielded over sixty scholarly articles that have helped to define and develop specialized scientific knowledge related to recommender systems and content tagging.

Herlocker, J., Konstan, J., Terveen, L., & Riedl, J. (2004). Evaluating collaborative filtering recommender systems. ***ACM Transactions on Information Systems*****. Vol 22, No 1. January**

This paper provides foundational information related to the descriptions of recommender systems. This reference is used to support the study's purpose, significance, and problem statement sections. It is also used as part of the data set selected for coding during the content analysis process.

Herlocker, et al, review the key evaluative criteria necessary to determine the usefulness of collaborative filtering-based recommender systems. In particular, the following criteria were identified during coding as being critically important to measure a recommender system's ability to successfully support the classification, retrieval, and discovery of information:

- the user tasks being evaluated
- the types of analysis and datasets being used
- the ways in which prediction quality is measured
- the evaluation of prediction attributes other than quality
- the user-based evaluation of the system as a whole.

Additionally, the authors define key success considerations that extend beyond the accuracy of recommender system results in order for the system to be useful (defined as the "suitability" of the recommendations). These include:

- Coverage – a measurement of the percentage of a dataset that the recommender system is able to provide predictions for.

- Confidence metrics – recommendations that can help users make more effective decisions
- Learning Rate - measures how quickly an algorithm can produce good recommendations
- Novelty/Serendipity - measures whether a recommendation provides a new discovery or novel (unexpected) result that is a viable possibility for a user.
- System Utility - user satisfaction with and performance using a recommender system.

This article has been cited by 157 other sources (via Google Scholar; retrieved January 2, 2007). Jonathan Herlocker has published 11 papers related to collaborative filtering and recommender systems. Joseph Konstan has published 20 papers related to recommender systems and user interface design. Loren Terveen has authored over 50 papers related to computer mediated communication. John Riedl has authored over 50 papers related to recommender and collaborative systems.

Joseph Konstan and John Riedl are Professors in the Department of Computer Science and Engineering at the University of Minnesota. Jonathan L. Herlocker is an Assistant Professor in the School of Electrical Engineering and Computer Science at Oregon State University. Loren Terveen is an Associate Professor in the Department of Computer Science and Engineering at the University of Minnesota.

Literature Describing Information Classification, Retrieval, and Discovery

Beilenberg, K, & Zacher, M. (2005). Groups in social software: utilizing tagging to integrate individual contexts for social navigation. ***Master's Thesis – University of Bremen.***

This resource provides a comprehensive overview of both content tagging and recommender systems as they relate to social networks in web-based applications. Emphasis is on how shared metadata creation - especially in the form of adding tags - enhances structured access to information. Beilenberg and Zacher explore the potential of tags to construct social networks in web-based applications as well as their use in fostering groups with shared contexts with a common understanding of tags and related resources. These shared contexts are the basis for deriving recommendations to realize social navigation. Much of the research of this paper is founded on theories from social network analysis, the field of social navigation and concepts like folksonomies and transactive memories that are used to propose a framework for social navigation based on tagging. This reference is used to support the study's purpose, significance, and problem statement sections.

While cited only 1 time via Google Scholar, the paper is frequently cited in many blogs of subject matter experts and in web communities dedicated to the discussion of user-generated metadata and content tagging. The paper is a thesis completed for a master of science degree in Digital Media at the Universität Bremen, GR. The thesis Advisor for this paper was Dr. Michael Koch, Technische Universität München.

Marlow, C., Naaman, M., Boyd, D., & Davis, M. (2006). Tagging paper, taxonomy, Flickr, academic article, toread. ***Proceedings of the seventeenth conference on Hypertext and Hypermedia - Odense, Denmark*** **2006. New York: ACM Press, 2006.**

This paper provides a comprehensive definition of social tagging systems as well as a taxonomy of key components of a content tagging system. This reference is used to support the study's purpose, significance, and problem statement sections. It is also used as part of the data set selected for coding during the content analysis process.

Marlow, et al. define social tagging systems as tools that “allow users to share their tags for particular resources” where “each tag serves as a link to additional resources tagged the same way by others.” They emphasize that social tagging systems rely on “shared and emergent social structures and behaviors” as well as “conceptual and linguistic structures of the user community.”

The authors outline how user tagging might be useful in many key web technologies to enhance the following common tasks:

- search and information retrieval
- information organization
- discovery and communication
- spam filtering/reducing effects of link spam
- improving on trust metrics
- identifying trends and emerging topics globally and within communities
- locating experts and opinion leaders in specific domains.

The authors describe how this potential is largely due to the social structure that underlies many of the current systems. They go on to define a model of tagging systems, specifically in the context of web-based systems that illustrate the possible benefits of these tools.

The authors provide a comprehensive taxonomy of tagging systems and their key components – system design and attributes (tagging rights, tagging support, tag aggregation) and user incentives (personal retrieval, contribution and sharing, opinion expression) that are referenced in the results, conclusions, and outcomes of this study. The taxonomy of tagging systems helps inform the analysis and design of tagging systems, and thus enables researchers to frame and compare evidence for the sustainability of such systems.

Additionally, the authors identify how user-generated tagging systems may offer a way to overcome the Vocabulary Problem where different users use different terms to describe the same things (or actions). As they point out, polysemy (when a single word has multiple related meanings) and synonymy (when different words have the same meaning) have the potential to hinder the precision and recall of tagging systems. However, the collaborative and transparent presentation of tag terms helps users identify these irregularities and see larger trends in tag terms that help stabilize – or flatten – variations caused by polysemy and synonymy problems. Finally, this paper concurs with other sources that emphasize that little academic research work has been invested in tagging systems to date.

This paper has been cited by 5 other sources (via Google Scholar; retrieved January 2, 2007). Cameron Marlow, Mor Naaman, and Danah Boyd work as research scientists at Yahoo Research Berkeley – a partnership with the University of California at Berkeley to explore and invent social media and mobile media technology and applications that will enable people to create, describe, find, share, and remix media on the web.

Cameron Marlow has published 14 papers related to information access and retrieval, Mor Naaman has published seven papers. Marc Davis is a professor at UC Berkeley's School of Information. He has published over fifty papers related to theory, design, and development of digital media systems for creating and using media metadata to automate media production and reuse. Danah Boyd has written over a dozen academic papers and op-ed pieces on various facets of online culture. Since 2003, her work has been cited on the subject of social networking in dozens of articles.

Morville, P. (2005). ***Ambient findability: what we find changes who we become.*** **Sebastopol: O'Reilly Media**

Morville's book provides foundational background related to information findability. In particular, topics related to the benefits and limitations of folksonomies, content tagging, and search systems are most relevant to this study.

The central thesis is that information literacy, information architecture, and usability are all critical components of an information rich environment where information is everywhere – it is ambient. Morville argues that only by planning and designing the best possible information classification, retrieval, and discovery systems will we be able to leverage the benefits of ubiquitous computing. He examines the convergence of increasing information creation with powerful distribution and access tools (internet, wireless, RFID) that make information increasingly ubiquitous and potentially more difficult to access despite its ambient presence.

The author describes strategies to make ubiquitous/ambient information more useful through strategies designed to enhance its classification, retrieval, and discovery. Two parallel themes emerge throughout the text - "you can't use what you can't find" and "what we find changes what we become."

This reference is used to support the study's purpose, significance, and problem statement sections. It is also used as part of the data set selected for coding during the content analysis process.

This book has been cited by 11 other sources (via Google Scholar; retrieved January 2, 2007). Peter Morville is a recognized expert in the information architecture field, and is an advocate for the importance of findability in web-based user experiences. He has published 8 papers on information architecture and design related topics. Morville holds an advanced degree in library and information science from the University of Michigan's School of Information, where he also serves on the faculty. He is president and founder of Semantic Studios, a leading information architecture, user experience, and findability consultancy. Peter Morville is also a founder and past president of the Information Architecture Institute.

Morville, P., & Rosenfeld, L. (2002). ***Information architecture for the world wide web.*** **Sebastopol: O'Reilly**

Widely cited as the quintessential text on information architecture, Morville and Rosenfeld's book is instrumental to this study because of the chapters defining the components of web-based information systems, search systems, and the role of user experience design in making powerful search technology as useful as possible. As such, this text provides much of the foundational information that describes "web-based search systems" and is cited throughout this study.

This reference is used to support the study's purpose and significance, and it is also used as part of the data set selected for coding during the content analysis process.

This book has been cited by 468 other sources (via Google Scholar; retrieved January 2, 2007). Peter Morville's expertise is outlined in the Ambient Findability source. Lou Rosenfeld is an information architecture researcher, practitioner, and consultant. He founded one of the first information architecture consultancies – Argus and Associates – the largest information architecture consultancy in the world. He the founder and publisher of Rosenfeld Media, a publishing house focused on producing user experience books. Rosenfeld has served on advisory boards for the Content Management Professionals group, the AIGA Experience Design Community, and the Interaction Design Association. He holds a Masters in Information and

Library Studies from The University of Michigan. Rosenfeld has contributed regular columns for CIO, Internet World, and Web Review magazines. Rosenfeld has written three books, published twenty articles, and has presented at over fifty professional conferences on topics related to the fields of information architecture and user experience design.

Key References Used to Support Methodology

Leedy P.D. & Ormrod J.E. (2005). *Practical Research: Planning and Design*. 8th edition. New Jersey, Pearson Merrill Prentice Hall

The Leedy and Ormrod text is referenced extensively throughout the study and is the primary resource used to guide framing the research design. The text provides strategies, tactics, and practical recommendations for the data collection and analysis work that was required for this study. Chapters 4 (Review of the Related Literature) and 5 (Planning Your Research Project) were particularly influential in shaping the Purpose and Method sections of the current paper.

This text has been cited by 477 other sources (via Google Scholar; retrieved January 6, 2007), and was originally published in 1974. The text is required reading for the University of Oregon's AIM Masters program.

Palmquist, M., Busch C., De Maret, P.S., Flynn, T., Kellum, R., Le, S., et al. (2006). *Content Analysis*. Writing@CSU. Colorado State University Department of English. Retrieved November 10, 2006 from the internet: http://writing.colostate.edu/guides/research/content/index.cfm

Palmquist et al., provides a process for conducting conceptual content analysis that is used in this study and cited throughout the Method section of this paper. Content analysis is a well established research method used in qualitative research. In particular, the eight step conceptual analysis process is used as the basis of the study's content analysis structure. The eight-step conceptual analysis method is selected because it provides a structured, step-by-step process for developing and documenting the conceptual content analysis.

The authors are affiliated with Colorado State University's Writing Center. Michael Palmquist is the Director of the Institute for Learning and Teaching, Co-Director of the Center for Research on Writing and Communication Technologies at Colorado State University. He has written 4 books and 14 peer refereed papers related to research writing as well as a host of conference papers and book chapters on the subject. (http://lamar.colostate.edu/~mp/cv.htm). Palmquist also teaches undergraduate writing courses and graduate seminars in rhetorical theory, computers and writing, research methodology, and nonfiction writing.

CHAPTER III. METHOD

This study is designed as a literature review (Leedy & Ormrod, 2005), and employs a conceptual content analysis methodology (Palmquist, et al., 2006). It maintains a qualitative and theoretical perspective so that data collection and analysis remain interpretive. It is designed so that a broad range of content related to the research topic may be analyzed based on predefined terms selected to focus the research.

The purpose of the study is to collect and analyze literature related to the role of user-generated metadata in enhancing the search systems of social software applications within two specific types of web-based information systems – content tagging and recommender systems. A literature review method (Leedy & Ormrod, 2005) is well suited for addressing this purpose because it facilitates the collection and review of existing literature produced by practitioners as well as from empirical research published in juried journals and periodicals.

The research process is organized into three phases, each with multiple sub-tasks: literature collection, data collection and analysis, and data presentation. An eight 8 step process for conceptual content analysis (Palmquist et al., 2006) is integrated into the data analysis and presentation phases. Each phase and sub-task is defined below.

LITERATURE COLLECTION PHASE

The literature review method is necessary for locating, describing, and summarizing similarities and differences found within the literature. It also provides an account of what has been published on a topic by accredited scholars and researchers in order to define established knowledge and ideas related to the topic and purpose of this study (Taylor & Proctor, 2005). Thus, the literature collection phase supports the research design of creating additional insights based on existing research conclusions and outcomes as identified in the analysis phase (Leedy & Ormrod, 2005).

Works of literature are selected using topic-based key words and an analysis of relevancy to this study's basic research question: "How can user-generated metadata enhance findability in web-based social software applications?"

An initial, broad search is conducted within the categories of web-based metadata, social computing, search tools and systems, content tagging tools, and recommender systems. These categories also serve as the initial groupings used to organize sources in the data analysis phase. This initial search is conducted using the University of Oregon Knight Library to access numerous academic journal databases defined below.

Each source is coded by key word and initially grouped into the categories defined in the data collection phase - web-based metadata, social computing, search tools and systems, content tagging tools, and recommender systems. Additional categories are added throughout the data analysis process as new ideas and relationships emerge and map to the study's goals and purpose. Some sources exist in multiple categories based on relationships between the source, key words, and other sources in the category. For example, multiple articles coded with the shared terms of "folksonomy," "2004," and "user-generated metadata" are placed into the categories of "content tagging" and "metadata." Additionally, if one of the articles was also coded with the term "search tool," then it would also exist in the "search" category.

Based on the initial literature survey and content screening, a more precise set of resources is established through the identification of twelve key words used to refine the search process (see Figure 1 below).

Key Words for Literature Search	
User-generated metadata	Social Computing
Social Networks	Content tagging
Folksonomies	Recommender systems
Search systems	Collaborative filtering
Information classification	Information retrieval
Information discovery	Social software

Figure 1: Key words used to guide the literature search process

The literature for this study is collected from the following sources accessed through the University of Oregon Knight Library "OneSearch" database aggregator:

- Academic Search Premier
- ACM Portal Digital Library
- Article First
- Business Source Premier
- ECO
- IEEE Computer Society Digital Library
- INSPEC
- Summit Union Catalog
- World Cat

Additional internet-based resources searched include:

- CiteUlike (http://www.citeulike.org/_
- Citeseer (http://citeseer.ist.psu.edu/?form=citesearch)
- Delicious (http://del.icio.us/)
- Google Scholar (http://scholar.google.com)

DATA COLLECTION AND ANALYSIS PHASE

Once the literature is collected, materials concerning content tagging and recommender systems are analyzed using conceptual analysis (Palmquist, 2006) to identify examples of user-generated metadata used in the content tagging and recommender systems of social software applications in order note relative strengths and weaknesses in relation to user search needs. Of the sixty sources reviewed for this study, twenty are selected for the conceptual content analysis section and are presented in Appendix B. The focus of the analysis is on three search-related factors as they appear in content tagging and recommender systems – information classification, retrieval, and discovery. Elements related to any one of these three factors, are identified, recorded and defined as a strength or a weakness based on their ability to enhance information findability (Morville, 2004). Details of the coding process plan follow.

Level of analysis

This researcher is coding both at the concept and word/phrase levels. Coding is conducted for single words, such as "metadata" and “tagging” as well as for sets of words or phrases, such as "user-generated metadata" and “content tagging” as these emerge from the reading of the literature. The goal is identify examples of user-generated metadata used in social software context in order note (1) relative strengths and (2) relative weaknesses in relation to one broad concept: user search needs, also known as findability.

Number of concepts to code for

Materials are coded for occurrences of key words and phrases relevant to a pre-defined set of concepts, based on three-search related factors as they appear in content tagging and recommender systems – (1) information classification, (2) retrieval, and (3) discovery. Elements related to any one of these three factors, are first identified and recorded and then defined as a strength or a weakness based on their ability to enhance information findability (Morville, 2004). In addition this study allows flexibility for the discovery of new terms and categories as these emerge in the data analysis phases, related to search (Palmquist, et al., 2006).

Existence v. Frequency

Coding is based on existence of concepts, since the frequency of the key words and phrases selected for this study does not necessarily yield additional insight into the relevance or usefulness of the source. Collected data are carefully read so that the analysis provides a more thorough description of the meaning and value of each source.

Distinguishing among concepts

Due to the amount of jargon, acronyms, and euphemisms related to the topics of the study, along with the fact that content tagging and recommender systems are relatively new with evolving terminology (Mathes, 2004), the level of generalization is flexible. The level of implication (Palmquist et al., 2006) allows related terms and phrases to be generalized so that related terminology may be tied to predefined coding terms and phrases.

Rules for Coding Material

After taking the generalization of concepts into consideration, translation rules are applied to streamline and organize the coding process for consistency and coherence (Palmquist, et al., 2006).

Translation rules are based on a comparison to a set of operating definitions, provided in this study.

Irrelevant Info

Irrelevant information, terms, and phrases that cannot be generalized and mapped to a predefined concept, as revealed in the set of Definitions (see Appendix A) presented in this study, are ignored.

Text Coding

Data identified during the data collection process is manually coded in order to document the analysis process. Data is noted within the predefined categories as it is identified. Additional categories are developed, as needed, and noted as emergent.

Analyze the Text

Once the coding is complete, ***results*** are presented and examined and conclusions are defined. The analysis process follows these steps:

1. Reviewing coding results to identify patterns, trends, and areas that require additional data collection.
2. Grouping results into the factors of information classification, retrieval, and discovery.
3. Organizing factor results into strengths and weaknesses as defined by their ability to enhance search-related outcomes as defined below.
4. Mapping the strengths and weaknesses of each factor to the two primary user-generated metadata methods identified for this study – content tagging and recommender systems.

DATA PRESENTATION PHASE

The data from the content analysis results are displayed in six tables (see Figures 3 – 8). Content in these tables consists of data collected in steps 2 and 3 of the content analysis process described above (grouping factors and noting strengths and weaknesses). In step 2, the elements of three search factors (classification, retrieval, and discovery) are identified in the context of two specific systems (content tagging and recommender systems) that leverage user-generated metadata to enhance search in web-based social software applications. In step 3 each element is further examined in relation to the core concept of findability and assigned a status of either strongly supporting or weakly supporting findability. The goal of presenting the data in this type of combined manner is to provide the context necessary to demonstrate the relationships between identified factors of content tagging and recommender in web-based social software and their strengths and weaknesses in relation to findability. The process of determining the status of either strong or weak for each factor element in relation to findability is as follows:

1. Literature selected for data analysis is coded for elements related to one of three pre-defined factors (1) information classification, (2) information retrieval, or (3) information discovery. Additionally, each source is coded to identify whether the source applies to (1) content tagging systems (folksonomies), (2) recommender systems, or (3) both systems.
2. The list of elements identified in the coding process is then examined in order to assign a status "strength" or "weakness" in relation to the core concept of findability. Elements that enhance findability are coded as a "strength" while elements that reduce findability are coded as a "weakness." The process of determining a strength or weakness status of each element is determined by an assessment of the textual context and evaluation of the

element per the outcomes and conclusions of each source. For example, elements defined by terms such as weakness, liability, flaw, risk, or other terms synonymous with weakness are coded as a weakness. Inversely, key terms such as strength, benefit, enhancement, or other term synonymous with strength are coded as strength.

3. These strength and weakness elements are grouped by each system-factor combination and presented in 6 tables. The tables are referenced so that readers may track back to original source materials if desired.

Method A **Factor A**	
Elements of findability strength	**Elements of findability weakness**
strength 1 (source)	weakness 1 (Source)
strength 2 (source)	weakness 1 (Source)
strength 3 (source)	weakness 3 (Source)
Etc.	Etc.

Figure 2: Sample system-factor table used in the Analysis of Data Section

The outcome of the study is a reference table designed to help user experience professionals evaluate and compare the potential of user-generated metadata when deployed through content tagging and recommender systems in social software applications. This tool provides an at-a-glace assessment of the reported strengths, weaknesses, and example applications of content tagging and recommender systems based on their ability to enhance information classification, retrieval, and discovery. The data presented in the outcome table includes summaries of key results. A template of the reference table is presented below (see Figure 3).

Findability Strengths, Weaknesses, and Recommended Applications of User-Generated Metadata in Content Tagging and Recommender Systems			
Systems and Factors	***Findability Strengths***	***Findability Weaknesses***	***Examples***
Content Tagging			
Classification	User generated	Uncontrolled	Flickr.com
Retrieval			
Discovery			
Recommender System			
Classification			
Retrieval			
Discovery			

Figure 3 – Template for outcome presentation of the Strengths, Weaknesses and Examples of User-Generated Metadata in Content Tagging and Recommender Systems

The intent of this matrix is to assist user experience design professionals when comparing two user-generated metadata search systems (content tagging and recommender) for web-based social computing applications. The comparative tool may be quickly and easily scanned to provide user experience designers with a decision matrix as they consider how to approach their work. In particular, the tool helps professionals to better understand the capabilities of user-generated metadata to improve search generally and its role in content tagging and recommender systems specifically. This outcome provides a significant benefit to user experience professionals because it provides the background and context necessary to determine the strengths and weaknesses of user-generated metadata systems.

CHAPTER IV. ANALYSIS OF DATA

This chapter introduces the results of the conceptual content analysis of 20 selected sources (see Appendix B). The goal of the content analysis is to identify elements of findability strengths and/or weaknesses for each of the three findability factors – information classification, retrieval, and discovery – as they pertain to content tagging and recommender systems. This information is organized by presenting findability strength and weakness elements for each of the six system-factor combinations. This structure of capturing the relationships between elements, factors, and systems is presented in a series of tables designed to convey the findings of the content analysis in a consistent and meaningful way, and to be used as context for understanding the outcomes of this study.

The conceptual analysis for this study uses a pre-defined set of coding concepts based on the three findability factors and two systems selected to define the findability benefits of user-generated metadata in web-based social applications. The findability factors are information classification, information retrieval, and information discovery. The systems are content tagging and recommender systems. References are presented by using an abbreviated code to represent each factor and method as displayed in Figure 4. These codes are then grouped into six system-factor combinations to document the relationship of each strength/weakness element identified for each method- factor combination.

Factor Codes	System Codes
IC = Information Classification	CT = Content Tagging System
IR = Information Retrieval	RS = Recommender System
ID = Information Discovery	
Factor and Method Combinations Used for Coding	
Content Tagging Combinations: CT-IC, CT-IR, CT-ID	Recommender System Combinations: RS-IC, RS-IR, RS-ID

Figure 4: System-factor codes and combinations for content analysis coding

From an initial set of 60 sources (articles, research papers, and case studies), twenty are selected for the data analysis because they identify clear strength and/or weakness elements of information classification, retrieval, and/or discovery factors related to content tagging or recommender systems. The concepts are coded for existence. The analysis methodology used to code these twenty references is based on the eight-step conceptual content analysis methodology defined in the Colorado State University Research Writing Lab website (Palmquist, et al. 2007). The specific implementation of these steps is outlined in the Data Analysis section of this study. The data analysis methodology and subsequent outcomes support the goal of framing new perspectives based on the outcomes, conclusions, and ideas provided in the set of selected sources. The literature selected for the content analysis represents a small portion of existing and evolving research in this field, and, as such, it is impossible for this sample to be representative of all findability strengths and/or weaknesses related to content tagging and recommender systems. The reader should apply this limitation to the analysis of data and conclusion sections of this study.

Table 1 identifies the specific factors and methods that are located in each source selected for the content analysis. This occurrence table is designed to provide a summary of the distribution of factors and methods that are reported in the sources used in the content analysis.

Distribution of Systems and Factors Within the Literature

Information Classification (IC), Information Retrieval (IR) and Information Discovery (ID) Factors Found in Content Tagging (CT) and Recommender Systems (RS)

Date	Sources	CT-IC	CT-IR	CT-ID	RS-IC	RS-IR	RS-ID
2005	Adomavicius, G. & Tuzhilin, A.				X	X	X
1989	Bates, M.	X		X			
2005	Bielenberg, K. & Zacher, M.		X				
2006	Bonhard, P. & Sasse, M. A.				X		X
2006	Campbell, G. & Fast, K.	X	X	X			
2006	Charron, C., Favier, J. & Li,, C.			X			
2003	Cosley, et al.				X	X	X
2006	Dye, J.	X	X	X			
2005	Economist Magazine					X	X
2006	Fox, C.	X					
2005	Golder, S, A. & Huberman, B, A.	X	X	X			
2004	Herlocker, et al.				X		
2004	Mathes, A.	X	X	X			
2006	Macgregor, G. & McCulloch, E.	X	X	X			
2006	Marlow, et al.	X	X	X			
2002	Melville, P., Mooney, R. & Nagarajan, R.				X	X	X
2005	Millen, D., Feinberg, J. & Kerr, B.		X	X			
2006	Porter, J.				X	X	X
2001	Schafer, J. B., Konstan, J. & Reidl, J.				X	X	X
2001	Swearingen, K. & Sinha, R.				X	X	X

Table 1: Distribution of system and factor data found in the sources selected for content analysis.

As revealed in Table 1, nine of the sources address Recommender systems and eleven of the sources address Content Tagging systems. Table 2 indicates the number of sources that address each of the six system-factor combinations. As noted, the distribution of information is relatively even.

System-Factor Combinations	Number of Sources
Content Tagging – Information Classification	Eight
Content Tagging – Information Retrieval	Eight
Content Tagging – Information Discovery	Nine
Recommender Systems – Information Classification	Eight
Recommender Systems – Information Retrieval	Seven
Recommender Systems – Information Discovery	Eight

Table 2: The number of sources that describe strength or weakness elements for each system-factor combination.

Tables 3 through 8 provide the key findings of the analysis, namely the specific findability elements for each system-factor combination. Each table includes citations of the sources referenced to describe, define, and support each element. The elements are presented as a strength or weakness for each system-method combination per the criteria defined in the Data Presentation section.

The following tables provide the specific findability strength and weakness patterns for each system-factor combination that was identified through the content analysis process. A summary of key results is provided for each system-factor combination following each table.

System 1: Content Tagging Factor 1: Information Classification	
10 Elements of findability strength	**6 Elements of findability weakness**
Real-time/immediate classification results and system feedback (Millen, Feinberg, and Kerr, 2005) (Golder and Huberman, 2005) (Mathes, 2004) (Bielenberg and Zacher, 2005) (Macgregor and McCulloch, 2006) (Fox, 2006)	**Lacks the controlled classification and hierarchical structure of taxonomies** (Macgregor and McCulloch, 2006) (Mathes, 2004) (Campbell and Fast, 2006)
Creates incentive for user classification and participation (Dye, 2006) (Golder and Huberman, 2005) (Mathes, 2004) (Bielenberg and Zacher, 2005	**Lacks synonym and homonym controls** (Macgregor and McCulloch, 2006) (Mathes, 2004) (Bielenberg and Zacher, 2005)
Low cognitive barrier to entry and participation (Bielenberg and Zacher, 2005) (Macgregor and McCulloch, 2006) (Mathes, 2004) (Campbell and Fast, 2006) (Golder and Huberman, 2005)	**Requires a large population of classifiers to generate useful results** (Dye, 2006) (Mathes, 2004) (Marlow, et al., 2006) (Campbell and Fast, 2006)
Provides cost effective system implementation and maintenance (Mathes, 2004) (Campbell and Fast, 2006)	**Allows for term ambiguity – spelling errors, multiple words used for a single tag description, personal notes “todo” “toread”** (Mathes, 2004) (Bielenberg and Zacher, 2005) (Dye, 2006)
Accommodates preferred human classification methods (vs. automated or machine defined) (Bielenberg and Zacher, 2005) (Millen, Feinberg, and Kerr, 2005) (Mathes, 2004)	**No Professional Oversight is used to manage or control classification standards** (Dye, 2006) (Mathes, 2004)
Provides a scalable, flexible, and adaptive design classification system design	**Individual classification choices are influenced by existing tags**

(Macgregor and McCulloch, 2006) (Dye, 2006) (Mathes, 2004) (Golder and Huberman, 2005)	(Cosley, et al., 2003),
An open, social, and inclusive method of classifying information (Macgregor and McCulloch, 2006) (Mathes, 2004) (Bielenberg and Zacher, 2005) (Dye, 2006)	
Content may belong to multiple categories for broader classification (Millen, Feinberg, and Kerr, 2005) (Mathes, 2004)	
Captures evolving language and adaptations of terms used by topic, user, and community for improved classification context (Mathes, 2004) (Bielenberg and Zacher, 2005) (Golder and Huberman, 2005)	
Accommodates both popular and rare classification terms and stabilizes with the most common terms (Golder and Huberman, 2005) (Mathes, 2004)	

Table 3: Strength and weakness elements identified for CT-IC

Summary of the Content Tagging Systems-Information Classification (CT-IC) Combination

Based on the number and diversity of strength and weakness elements identified in this study, the greatest findability benefit across all system-factor combinations is the ability for users to classify information for future retrieval using content tagging methods. The key strength elements supporting this system-factor combination are:

- Real-time/immediate classification results and system feedback
- Creates incentive for user classification and participation
- Low cognitive barrier to entry and participation
- Provides cost effective system implementation and maintenance

- Accommodates preferred human classification methods (vs. automated or machine defined)
- Provides a scalable, flexible, and adaptive design classification system design
- An open, social, and inclusive method of classifying information
- Content may belong to multiple categories for broader classification
- Captures evolving language and adaptations of terms used by topic, user, and community for improved classification context
- Accommodates both popular and rare classification terms and stabilizes with the most common terms

Of these elements, content supporting "Real-time/immediate classification results and system feedback" appeared most often in the literature. Mathes (2004) provided a typical explanation:

> "The degree to which these systems bind the assignment of tags to their use - in a tight feedback loop - is that kind of difference. Feedback is immediate. As soon as you assign a tag to an item, you see the cluster of items carrying the same tag. If that's not what you expected, you're given incentive to change the tag or add another. This tight feedback loop leads to a form of asymmetrical communication between users through metadata" (p. 9).

System 1: Content Tagging Factor 2: Information Retrieval	
5 Elements of findability strength	**3 Elements of findability weakness**
Common, "Basic Level" categorization patterns emerge (Golder and Huberman, 2005)	**Search results lack precision of specialized search engines or Boolean searches** (Macgregor and McCulloch, 2006) (Mathes, 2004) (Campbell and Fast, 2006)
Tag terms "stabilize" and common terms emerge (Golder and Huberman, 2005) (Mathes, 2004)	**Breadth of recall (related tags) may be overwhelming (distract with cognitive noise)** (Dye, 2006) (Golder and Huberman, 2005) (Mathes, 2004)
Specialized or trusted content emerges through tag pattern visibility (Mathes, 2004) (Marlow, et al., 2006) (Golder and Huberman, 2005)	**Results may be manipulated through unscrupulous classification (tagging) methods** (Cosley, et al., 20030

Provides information discovery through serendipitous finding (Marlow, et al., 2006) (Mathes, 2004) (Bates, 1998) (Macgregor and McCulloch, 2006)	
Provides breadth and depth/precision and recall simultaneously (Mathes, 2004) (Golder and Huberman, 2005) (Marlow, et al., 2006) (Macgregor and McCulloch, 2006)	

Table 4: Strength and weakness elements identified for CT-IR

Summary of the Content Tagging Systems-Information Retrieval (CT-IR) Combination

The ability to use content tagging systems to retrieve information using self-assigned metadata labels (tags) or by using the tag terms of other users is a key strength of content tagging systems (Mathes, 2004). The key strength elements supporting this system-factor combination are:

- Common, “Basic Level” categorization patterns emerge
- Tag terms “stabilize” and common terms emerge
- Specialized or trusted content emerges through tag pattern visibility
  Provides information discovery through serendipitous finding
- Provides breadth and depth/precision and recall simultaneously

Of these elements, content related to the ability of tagging systems to “Provides breadth and depth/precision and recall simultaneously” in their search results appeared most often in the literature. A relevant passage supporting this result is noted:

> “There are positive lessons to be learned from the interactivity and social aspects exemplified by collaborative tagging systems. Even if their utility for high precision information retrieval is minimal, they succeed in engaging users with information and online communities, and prove useful within PIM contexts. The need to engage users in the development of controlled vocabularies has been recognised by vocabulary experts (Abbott, 2004; Mai, 2004) and collaborative tagging systems could potentially provide a base model for such approaches. Ultimately the dichotomous co-existence of controlled vocabularies and collaborative tagging

systems will emerge; with each appropriate for use within distinct information contexts" (Macgregor and McCulloch, 2006)

System 1: Content Tagging Factor 3: Information Discovery	
4 Elements of findability strength	**4 Elements of findability weakness**
Multiple access/pivot points to related content (Macgregor and McCulloch, 2006) (Mathes, 2004) (Marlow, et al., 2006) (Millen, Feinberg, and Kerr, 2005)	**Competing grouping, categories, and terms** (Golder and Huberman, 2005) (Mathes, 2004) (Macgregor and McCulloch, 2006)
Locate other users/groups with related interests and content – Aids Community building/social networks (Marlow, et al., 2006) (Mathes, 2004) (Schafer, Konstan, and Reidl, 2001) (Bielenberg and Zacher, 2005)	**Categories and terms are subjective** (Bielenberg and Zacher, 2005) (Golder and Huberman, 2005) (Mathes, 2004)
Exposure to related but unexpected content (Macgregor and McCulloch, 2006) (Mathes, 2004) (Marlow, et al., 2006)	**Dependent on large community of users tagging content related to original search – scarcity problem.** (Bielenberg and Zacher, 2005) (Dye, 2006)
Supports browsing – berrypicking – over searching (Bates, 1998)	**Lacks expert or specialized results managed by domain experts** (Marlow, et al., 2006) (Mathes, 2004)

Table 5: Strength and weakness elements identified for CT-ID

Summary of the Content Tagging Systems-Information Discovery (CT-ID) Combination

The serendipitous discovery of related content is an oft-cited benefit of content tagging methods that appeared often in the literature selected for this study. By exposing the classification labels (tags) that other users have used to classify a particular artifact, the user is able to learn new terminology and context about a particular topic of interest. When these community-contributed classifiers (tags) are presented as hyperlinks to other content tagged with the same term, the searcher may quickly traverse or "berrypick" (Bates, 1989) their way through the results to discover unexpectedly relevant information. This navigational way finding structure is most often dubbed "pivot browsing" in the literature. The key strength elements supporting this system-factor combination are:

- Multiple access/pivot points to related content
- Locate other users/groups with related interests and content – Aids Community building/social networks
- Exposure to related but unexpected content
- Supports browsing – berrypicking – over searching

Of these elements, content supporting the concept serendipitous discovery through the exposure of "Multiple access/pivot points to related content" appeared most often in the literature as in this passages from Millen, Feinberg, and Kerr (2005):

> **"**There is a bias toward increased transparency in these tools. Although [tag] collections are personally created and maintained, they are typically visible to others. A number of user interface elements allow social browsing of the [tag] space. For example, user names are "clickable" links; clicking on a name reveals the collection for that user. This allows someone to get a sense of the topics of interest for a particular user. Similarly, tags are also clickable, and when selected will result in a list of [content elements] that share that tag. This is a useful way to browse through the entire collection to see if it includes information sources of interest. The ability to reorient the view by clicking on tags or user names, called pivot browsing, provides a lightweight mechanism to navigate the aggregated tag collection" (p. 12).

System 2: Recommender Systems Factor 1: Information Classification	
3 Elements of findability strength	**10 Elements of findability weakness**
Classification based on overt user selections, preferences, and previous	**Machine/algorithm-based – lacks contextual, human classification**

behavior (Porter, 2006) (Schafer, Konstan, and Reidl, 2001) (Melville, Mooney, and Nagarajan, 2002)	(Adomavicius and Tuzhilin, 2005) (Cosley, et al., 2003) (Schafer, Konstan, and Reidl, 2001)
Multiple classification methods applied (Implicit and explicit based) (Adomavicius and Tuzhilin, 2005) (Schafer, Konstan, and Reidl, 2001) (Herlocker, et al., 2004)	**Difficult and expensive to design, configure, deploy, and maintain** (Porter, 2006) (Cosley, et al., 2003) (Schafer, Konstan, and Reidl, 2001)
Classifications built by multiple related (nearest neighbor) user choices (Bonhard and Sasse, 2006)	**Cold Start Problem - there are only a few ratings on which to base recommendations** (Adomavicius and Tuzhilin, 2005) (Porter, 2006) (Herlocker, et al., 2004)
	New User Problem – user must rate enough items to yield accurate recommendations (Adomavicius and Tuzhilin, 2005)
	New Item Problem – new items need to be rated enough to be recommended (Adomavicius and Tuzhilin, 2005)
	Overspecialization – narrow, obvious recommendations (Adomavicius and Tuzhilin, 2005)
	Intrusiveness – Classification prompts can get in the way of other critical user tasks. (Adomavicius and Tuzhilin, 2005)
	Lack of incentive – classification prompts require incentive for the user to provide preferences/feedback (Adomavicius and Tuzhilin, 2005) (Cosley, et al., 2003) (Schafer, Konstan, and Reidl, 2001)
	Privacy Concerns – when no transparency in recommendations methods (Cosley, et al., 2003) (Schafer, Konstan, and Reidl, 2001)
	Recommendations may be manipulated to

	present skewed recommendations (Cosley, et al., 2003)

Table 6: Strength and weakness elements identified for RS-IC

Summary of the Recommender Systems-Information Classification (RS-IC) Combination

As defined in previous sections of this study, recommender systems enable the user to classify information through both overt and covert methods. While this study is limited to overt or explicit metadata creation in recommender systems, it is important to note that much of the literature selected for this study addresses both implicit and explicit metadata extraction techniques. Also, many of the recommender systems that are evaluated and discussed in the literature employ more than one classification model, and typically discuss the merits of various hybrid designs that combine both overt and covert methods of soliciting user metadata for classification purposes.

As indicated in the Limitations section, this study focuses on overt methods of providing metadata to classify information. Common examples of overt metadata prompts in recommender systems include user questionnaires or profiles designed to capture user needs and preferences, providing a rating/ranking scale to allow users to score their opinion about a particular content item, or rating the value of other rating resources (people, tools, web sites) that provide an additional classification weight. The user and item metadata gathered through these methods are used by the system to aid the findability of new and novel items. In these examples, the user contributed ratings serve as metadata about both the user and the items rated to improve the accuracy of the system-generated recommendations. The key strength elements supporting this system-factor combination are:

- Classification based on overt user selections, preferences, and previous behavior
- Multiple classification methods applied (Implicit and explicit based)
- Classifications built by multiple related (nearest neighbor) user choices

Of these elements, content supporting the concept of "Classification based on overt user selections, preferences, and previous behavior" appeared most often in the literature.

> "Recommender systems help overcome information overload by providing personalized suggestions based on a history of a user's likes and dislikes. There are two prevalent approaches to building recommender systems — Collaborative Filtering (CF) and Content-based (CB) recommending. CF systems work by collecting user feedback in the form of ratings for items in a given domain and exploit similarities and differences among profiles of several users in determining how to recommend an item. On the other hand, content-based methods provide recommendations by comparing representations of content contained in an item to representations of content that interests the user" (Melville, Mooney, and Nagarajan, 2002, p.1).

Despite these strengths, there are many drawbacks to the information classification models currently employed in recommender systems. The most oft-cited drawbacks are the "cold start" problem, the "new user" problem, and related "new item" problem that are inherent in most recommender systems. Much of the literature written to address weaknesses in the accuracy of recommender systems are focused on these issues. Briefly, the cold start problem occurs early in the development of a recommender system or as significant content is added to an existing recommender system because there are not enough user or item ratings to generate useful recommendations. The new user problem occurs when there is a new user or infrequent visitor who has not generated sufficient preference metadata to allow the system to provide accurate recommendation matches to useful content. Likewise, the new item problem occurs when a new content item is added to the system and cannot be recommended because not enough users have evaluated it. Additional weakness elements associated with the information classification capabilities of recommender systems are:

- Machine/algorithm-based – lacks contextual, human classification
- Difficult and expensive to design, configure, deploy, and maintain
- Overspecialization – narrow, obvious recommendations

- Intrusiveness – Classification prompts can get in the way of other critical user tasks.
- Lack of incentive – classification prompts require incentive for the user to provide preferences/feedback
- Privacy Concerns – when no transparency in recommendations methods
- Recommendations may be manipulated to present skewed recommendations

While recommender systems can leverage explicitly collected user-generated metadata to classify content, they are not always a reliable method for generating accurate results (Adomavicius & Tuzhilin, 2005). Only when recommender systems have collected a substantial amount of classification metadata from the user and then effectively mapped the information to other user and item preferences, can they yield useful recommendations.

System 2: Recommender Systems Factor 2: Information Retrieval	
5 Elements of findability strength	**6 Elements of findability weakness**
Transparency of criteria used to generate recommendation can generate trust, adoption, and usage. (Herlocker, et al., 2004) (Porter, 2006)	**Obviousness of Results** (Adomavicius and Tuzhilin, 2005)
Leverages ratings from similar (nearest-neighbor) users to enhance accuracy (Adomavicius and Tuzhilin, 2005)	**Limited Accuracy/Incorrect Recommendations** (Economist, 2005) (Schafer, Konstan, and Reidl, 2001)
Hybrid design - collaborative filtering and content-based methods improve accuracy (Adomavicius and Tuzhilin, 2005) (Melville, Mooney, and Nagarajan, 2002)	**New user /cold start problem** (Adomavicius and Tuzhilin, 2005) (Porter, 2006) (Herlocker, et al., 2004)
Contextual/ephemeral personalization – recommendations are contextually relevant and personal (Schafer, Konstan, and Reidl, 2001) (Adomavicius and Tuzhilin, 2005)	**New item problem** (Adomavicius and Tuzhilin, 2005)

Reduced organizational maintenance – allows the system to make content placement decisions (Porter, 2006)	**Sparsity/scarcity of participants and ratings** (Adomavicius and Tuzhilin, 2005)
	Inflexible design – recommendations generated by algorithm logic (Adomavicius and Tuzhilin, 2005) (Bates, 1998)

Table 7: Strength and weakness elements identified for RS-IR

Summary of the Recommender Systems-Information Retrieval (RS-IR) Combination

Unlike typical search tools that prompt the user for a specific term or phrase to generate desired results, recommender systems attempt to proactively present relevant recommendations within the context of the user's real-time browsing experience (Schafer, Konstan, and Reidl, 2001). This proactive "push" of recommended content prevents users from having to submit a search query to locate related information. From the user's perspective, this approach is passive. The method and design of placing recommendations is ultimately a social activity because the recommendations are based on the ratings of other users who share common rating preferences or profile characteristics (Adomavicius and Tuzhilin, 2005). This is why recommender systems are often considered collaborative, social software tools (Porter, 2006). In recommender systems, information is "retrieved" only after the user actively selects a recommendation that has been "pushed" based on previous behavior or preferences.

As noted in the results table, the key strength elements supporting this system-factor combination are:

- Transparency of criteria used to generate recommendations can generate trust, adoption, and usage.

- Leverages ratings from similar (nearest-neighbor) users to enhance accuracy
- Hybrid design - collaborative filtering and content-based methods improve accuracy
- Contextual/ephemeral personalization – recommendations are contextually relevant and personal
- Reduced organizational maintenance – allows the system to make content placement decisions

The weakness elements of information retrieval in recommender systems are similar to the weakness elements noted for information classification above. The same limitations to information classification – cold start, new user, and new item problems – will effect the accuracy of results and, hence, the user's ability to successfully retrieve information related to predicted needs, preferences, or related content. The "obviousness" of results may also be detrimental to information retrieval needs. If a user receives a recommendation for an item that is already known, the recommendation may not provide as much value as one that is unexpected or novel.

The key weakness elements related to information retrieval in recommender systems are:

- Obviousness of Results
- Limited Accuracy/Incorrect Recommendations
- New user /cold start problem
- New item problem
- Scarcity/scarcity of participants and ratings
- Inflexible design – recommendations generated by algorithm logic

System 2: Recommender Systems Factor 3: Information Discovery	
6 Elements of findability strength	**5 Elements of findability weakness**
Enables serendipitous browsing and information discovery (Economist, 2005) (Herlocker, et al., 2004) (Schafer, Konstan, and Reidl, 2001)	**Lack of or too broad of context in recommendations** (Adomavicius and Tuzhilin, 2005) (Dye, 2006) (Bielenberg and Zacher, 2005)

(Porter, 2006) (Herlocker, et al., 2004) (Melville, Mooney, and Nagarajan, 2002)	
Provides Passive/Organic Recommendations (Schafer, Konstan, and Reidl, 2001)	**Intrusiveness of recommendation placement** (Adomavicius and Tuzhilin, 2005)
Crates implicit and explicit social connections – matching users builds community (Schafer, Konstan, and Reidl, 2001) (Economist, 2005)	**Poor Design and Placement of Recommendation Outputs (usability)** (Adomavicius and Tuzhilin, 2005) (Schafer, Konstan, and Reidl, 2001)
Commercial value through cross-selling and marketing opportunities (Economist, 2005) (Schafer, Konstan, and Reidl, 2001)	**Loss of user trust and loyalty if recommender techniques not disclosed** (Schafer, Konstan, and Reidl, 2001) (Herlocker, et al., 2004)
Effective systems build user trust and loyalty in the service/brand (Schafer, Konstan, and Reidl, 2001) (Bielenberg and Zacher, 2005) (Herlocker, et al., 2004) (Swearingen and Sinha, 2001) (Bonhard and Sasse, 2006) (Marlow, et al., 2006	**Inflexible system design – lack of user manipulation to effect recommendations** (Adomavicius and Tuzhilin, 2005)
Supports natural "berrypicking" information retrieval patterns (Bates, 1998)	

Table 8: Strength and weakness elements identified for RS-ID

Summary of the Recommender Systems-Information Discovery (RS-ID) Combination

By their design, the goal of recommender systems is to deliver new, novel, and useful content to users in contextually meaningful ways. The desired effect is one of information discovery. Hence, information discovery is the findability factor that received the greatest number of strength elements for recommender systems. In particular, two strengths were common across many sources selected for the content analysis – serendipitous browsing/discovery and the ability for accurate recommender systems to build trust in the system and loyalty to the web application/brand.

As noted in the results table, the key strength elements supporting this system-factor combination are:

- Enables serendipitous browsing and information Discovery
- Provides Passive/Organic Recommendations
- Crates implicit and explicit social connections – matching users builds community
- Commercial value through cross-selling and marketing opportunities
- Effective systems build user trust and loyalty in the service/brand
- Supports natural "berrypicking" information retrieval patterns

> "Novelty & Serendipity increase user confidence in the system. A serendipitous recommendation helps the user find a surprisingly interesting item he might not have otherwise discovered." (Herlocker, et al., 2004)

The weakness elements for information discovery in recommender systems are predictably based on their strengths as well as the limitations defined in the information classification and retrieval factors above. Low accuracy renders information discovery useless if the user is not compelled to explore the recommendations provided by the system. This weakness is then compounded by a lack of trust in the system which can result in the perception of recommender functionality as an intrusive and distracting annoyance rather than a useful findability resource.

As noted in the results table, the key weakness elements of information discovery in recommender systems are:

- Lack of or too broad of context in recommendations
- Intrusiveness of recommendation placement
- Poor Design and Placement of Recommendation Outputs (usability)
- Loss of user trust and loyalty if recommender techniques not disclosed
- Inflexible system design – lack of user manipulation to effect recommendations

Findability Strength and Weakness Patterns

The strength and weakness elements identified in the content analysis reveal patterns that explain the potential of each system (content tagging and recommender systems) to enhance findability through the use of user-generated metadata. These observations are based solely on the results of this study and are not derived from a single source or the broader collection of literature selected for this study.

Based on an accounting of the strength and weakness elements in each of the six system-factor combinations, the most consistent strength of content tagging systems is the ability to classify information while the most consistent strength of recommender systems is the ability to discover information. The most consistent weakness of recommender systems is the ability to classify information while the most consistent weakness of content tagging systems is the ability to classify information.

Further, the overall strength/weakness balance (total number of strength elements minus total number of weakness elements for all factors) for all content tagging (CT) factors is +5 while the overall strength/weakness balance for all recommender system (RS) factors is -7. One interpretation of this pattern is that content tagging systems enable greater findability potential than recommender systems. However, this statement would need to be evaluated further using more quantitative measures to ensure statistical relevancy.

Another view of this result is presented in Table 9 below. By subtracting the number of weakness elements from the number of strength elements for each system-factor combination, a measure of overall findability strength is implied.

Strength/Weakness Balances For Each System-Factor Combination	
Grouped by Each System-Factor	Descending From Strength to Weakness
CT & IC = +4 (strength)	CT & IC = +4 (strength)
CT& IR = +1 (strength)	CT & IR = +1 (strength)
CT& ID = 0 (even)	RS & ID = +1 (strength)
RS & IC = -7 (weakness)	CT& ID = 0 (even)
RS & IR = -1 (weakness)	RS& IR = -1 (weakness)
RS & ID = +1 (strength)	RS& IC = -7 (weakness)

Table 9: Strength and weakness balances for each system-factor combination

Based on this simple accounting strategy and based on a limited data set, content tagging systems may be assumed to provide greater overall findability strength than recommender systems. Additionally, there are far more weaknesses elements than strength elements recorded for recommender systems - specifically in their ability to classify and retrieve information.

Table 10 below presents the summarized view of the strengths and weaknesses of each system, coupled with examples of applications that utilize user-generated metadata in content tagging and recommender systems. This table is designed as the primary outcome for user-experience professionals who must define, create, and deploy the user experience of web-based social software applications that leverage user-generated metadata.

Strengths, Weaknesses, and Examples of User-Generated Metadata in Content Tagging and Recommender Systems			
Systems and Factors	**Key Findability Strengths**	**Key Findability Weaknesses**	**Example Applications**
Content Tagging			
Classification	User-classified content is personally and contextually relevant Captures unique user and community generated vocabulary, specialized terminology, and jargon Easy to use - low barrier to entry, low cognitive/learning costs Incentive – Users typically classify for their own personal needs while their tags benefit all system users.	Uncontrolled, ambiguous, and unreliable categorization Requires a large population of classifiers to generate useful results Allows for classifier term ambiguity – spelling errors, multiple word tag descriptions, and personal notes such as "todo" "toread"	http://del.icio.us/ Social bookmarking through tagging http://flickr.com/ Social photo management and discovery through tagging www.youtube.com Video sharing and discovery - includes tagging http://technorati.com/ Blog search to rate and categorize content using tags http://myweb.yahoo.com/ Search engine with integrated tagging tools. www.Citeulike.org Research tool that utilizes content tagging as dominant search tool http://www.connotea.org/ Another research tool that utilizes
Retrieval	Feedback - tight feedback loop (users see results of tagging immediately) Provides breadth and depth/precision and recall	Search results lack precision of specialized search engines or Boolean searches Breadth of recall (related tags) may be overwhelming (distract	

	simultaneously Specialized or trusted content tags and users emerges through tag pattern visibility	with cognitive noise)	content tagging as dominant search tool http://www.slideshare.net/ Slideshow (PPT) sharing and organizing using tags
Discovery	Multiple access/pivot points to related content Locate other users/groups with related interests and content – aids community building/social networking Supports natural browsing – berrypicking – over searching	Lacks expert or specialized results managed by domain experts Competing groupings, categories, and terms Unorganized presentation of information may be time consuming to comprehend	
Recommender Systems			
Classification	Classification based on overt user selections, preferences, rankings, and previous behavior	Machine/algorithm-based – lacks contextual, human classification Difficult and expensive to design, configure, deploy, and maintain Lack of incentive – classification prompts require incentive for the user to provide preferences/feedback	www.Amazon.com The pioneering recommender service that provides many examples of explicit prompts to generate personalized recommendations www.Dig.com News aggregator that leverages user rankings to personalize and recommend related news http://pandora.com/

			Music recommendations based on explicit user rankings
Retrieval	Transparency of criteria used to generate recommendation can generate trust, adoption, and usage Contextual/ephemeral personalization – recommendations are pushed based on relevant personal inputs	Limited Accuracy/Incorrect Recommendations Inflexible design – recommendations are generated by algorithmic logic and lack human inputs	www.netflix.com Video rental service that prompts users for film ratings to make recommendations www.Ebay.com Users may rank buyers and sellers as a mechanism for establishing credibility in a virtual marketplace (community)
Discovery	Enables serendipitous browsing and information discovery Pushes Passive/Organic Recommendations Crates implicit and explicit social connections – matching users builds community	Inaccurate recommendations Task intrusiveness from recommendations placed in user interface Loss of user trust and loyalty if recommender techniques or rationale for recommendations not disclosed	http://answers.yahoo.com/ Participants gain credibility by posting answers to questions posited to the system. Answers are rated, and answerer credibility increases with positive feedback.

Table 10 – Strengths, Weaknesses, and Examples of Content tagging and Recommender Systems That Use User-Generated Metadata

Appendix D includes specific text passages selected to identify strength and weakness elements for each system-factor combination. They are included for reference so that readers may glean a broader understanding of each element within the context of the specific source.

CHAPTER V. CONCLUSIONS

This study is designed for user experience professionals who need to understand findability strengths and weaknesses of web-based social software applications that leverage user-generated metadata through content tagging and/or recommender systems. This study provides the background and context for understanding what user-generated metadata is, how it enhances findability, and its role in content tagging and recommender systems. The outcome of the study is designed to help user experience professionals make informed decisions regarding the potential findability strengths and weaknesses of each system.

User-generated metadata has potential to enhance information classification, retrieval, and discovery in web-based information systems. While this study analyzes this potential within the limited context of content tagging and recommender systems, the number new web-based applications that leverage user-generated metadata is rapidly growing across industries, services, and communities. There is clearly growing interest in the social networking opportunities that these methods provide and increased adoption of technologies that enable this functionality. In the course of reviewing literature for this study, it is clear that this is a new field of study with limited quantitative studies. More quantitative research is needed in this field to better measure the tradeoffs between top-down controlled vocabularies and bottom-up user driven tools designed to aid classification, retrieval, and discovery (Mathes, 2004).

Through web-based applications designed to solicit user descriptions and rankings of content, metadata can be created, viewed, and modified by users to enhance the usefulness of the information system (Kimball, 1998). The active participation of users in the process of information creation, classification, and discovery (Mathes, 2004) is a core characteristic of social software designed to enable social computing (Millen and Patterson, 2002). When integrated into a larger information retrieval system composed of search, navigation, and information design sub-systems, user-generated metadata may enhance the user experience by adding an additional dimension to information access (Morville, 2002). Collaborative classification tools provide a mechanism for the creation of personal metadata that may be used to organize content in a more personally relevant format (BEA, 2006).

Content tagging systems enable users to organize the vastness of the Web.

> "Tagging lets us organize the Net our way. By looking over the public field of tags, we can see which tags are most frequently used and how they relate. There's an altruistic appeal to tagging as well. Tagging at public sites can give you a sense that you're adding to a shared stream of knowledge" (Rainie, 2007).

When personal tags become exposed to and searchable by a larger user community, their value extends beyond the individual to the potential benefit of other system users (Mathes, 2004). This aspect of tagging is called collaborative classification (Golder & Huberman, 2005). When shared within a larger community, these personal tags provide a way for others to see related terms and discover related content. In this sense, it provides a benefit to the user by allowing customization of information identification and organization while benefiting the group by creating a classification system that reflects the organic evolution of new terminology and specialized group language (Sturtz, 2004). In this collective context, users learn from the tag terms produced by others and may use them to enhance their own content retrieval and organization strategies by adopting the same or similar terms to classify related content (Morville, 2005). Typically, tag terms are presented as hyperlinks that lead to content that has been tagged by the specific term or just to the content of a specific user or user group who have used the tag. It provides both a many-to-one and one-to-many connection to content (Sturtz, 2004).

Recommender systems are often used in e-commerce web sites that attempt to sell new products. Recommender systems are not limited to commercial web sites and may also be used as an information aggregation device to connect people to information in any online community through a variety of interaction design mechanism (Schafer, Konstan & Riedl, 2001). In recommender systems, the most common form of user-defined metadata is an explicit ranking or rating score of an informational element (product, song, film, seller, review, etc.) that is used to define a unique user profile, needs, or preferences so that the system may generate accurate recommendations. Recommender systems help overcome information overload by providing personalized suggestions based on a history of a user's likes and dislikes (Herlocker, et al., 2004). There are two prevalent approaches to building recommender systems — Collaborative Filtering (CF) and Content-based (CB) recommending (Melville, Mooney, and Nagarajan, 2002). CF systems work by collecting user feedback in the form of ratings for items in a given domain and exploit similarities and differences among profiles of several users in determining how to recommend an item. On the other hand, content-based methods provide recommendations by comparing representations of content contained in an item to representations of content that interests the user (Melville, Mooney, and Nagarajan, 2002).

The three findability factors selected for this study – information classification, retrieval, and discovery – are the key system interaction points of content tagging and recommender systems where user-generated metadata is created, referenced, and used to discover additional content that share similar metadata. In content tagging systems, user-generated metadata is often integrated into the search tools in order to generate search results that include related tags. For example, conducting a search for information about "poodles" using he content tagging service Delicious (www.del.icio.us) not only provides results (urls) of pages about poodles, but also provides the tags other users applied to the pages such as "dogs" "grooming" "diet" "pets" "dog_health" etc. By exposing these community-generated tags, content tagging systems provide additional semantic context about a topic that may be of potential interest to others. Because these additional tags are presented as hyperlinks, users may "pivot" their search from tag-to-tag and continue the process of both broadening their knowledge about the topic of interest and narrowing their search results simultaneously. These additional tags allow the user to explore unintended but related content thus providing an opportunity for serendipitous information discovery. Once the desired page about poodles is located, the user may assign specific tags which serve as a bookmark for future retrieval. The tags also contribute to the ongoing community classification process (descriptive information about poodles) commonly referred to as a "folksonomy." In this example, the act of tagging the content is the "information classification" factor, the act of conducting a search using the tags is the "information retrieval" factor, and the act of discovering new and related content through pivot browsing is the "information discovery" factor.

In recommender systems, user-generated metadata is most often provided as a preference or an opinion about a specific information artifact. While most recommender systems employ both overt and covert methods of capturing user preferences, this study focuses on overt/explicit metadata contributions which typically yield more accurate cues to predict user needs. An example of user-generated metadata in recommender systems may be found in Netflix.com - the popular movie rental service. Netflix customers are asked to rate movies using an interactive rating tool that prompts users to rate films on a 5 star scale. Users may also select a "not interested" button that indicates less than a 1 star interest in a film. These rankings serve as metadata that define a user's film preferences as well as provide a score for the film itself. Proprietary collaborative filtering algorithms then look for preference patterns to calculate the characteristics of the films that typically receive high ratings (genre, actor(s), setting, sound tract, date made, etc.) for specific types of users. Also included in the calculations are matches between users with similar tastes. Netflix presents users with recommendations throughout the browsing experience. There is a section of the service titled "Movies You'll Love" which presents recommendations along with the reasons why the film was recommended. This contextually placed information defining the reasons why a film was recommended, is an important design consideration for establishing trust and credibility in the recommender system (Schafer, Konstan, and Reidl, 2001). Browsing films in a specific category such as "comedies" or "thrillers' always includes prominent recommendations unique to that category. In this brief example, the act of overtly rating films is the "information classification" factor, the act of receiving recommendations is the "information retrieval" factor, and the process of exploring recommendations or reading reviews of users with similar tastes is the "information discovery" factor.

The trade-offs between top-down, controlled classification methods and bottom-up, user-defined methods may be viewed as contradictory or complementary depending on the intended goals of the information system. This tradeoff is well characterized by Mathes (2004):

> "A folksonomy represents simultaneously some of the best and worst in the organization of information. Its uncontrolled nature is fundamentally chaotic, suffers from problems of imprecision and ambiguity that well developed controlled vocabularies and name authorities

> effectively ameliorate. Conversely, systems employing free-form tagging that are encouraging users to organize information in their own ways are supremely responsive to user needs and vocabularies, and involve the users of information actively in the organizational system" (p. 12).

Clearly there are numerous difficulties with collaborative tagging. As noted, most of these difficulties originate from the absence of those properties that have come to characterize controlled vocabularies (Macgregor and McCulloch, 2006). Collective tagging, then, has the potential to exacerbate the problems associated with the fuzziness of linguistic and cognitive boundaries inherent in language. The participatory nature of collaborative classification systems inevitably generate idiosyncratic personal tags that are ignored as well as those that become widely agreed upon. However, there is also opportunity to learn from one another through the process of sharing and organizing information in a public setting. (Golder and Huberman, 2005)

There are positive lessons to be learned from the interactivity and social aspects inherent in collaborative tagging systems. Even if their utility for high precision information retrieval is minimal, they succeed in engaging users with information and online communities, and prove useful within personal information management contexts (Macgregor and McCulloch, 2006). The need to engage users in the development of controlled vocabularies has been recognised by vocabulary experts (Abbott, 2004; Mai, 2004) and collaborative tagging systems could potentially provide a base model for such approaches.

> "Ultimately the dichotomous co-existence of controlled vocabularies and collaborative tagging systems will emerge; with each appropriate for use within distinct information contexts: formal (e.g. academic tasks, industrial research, corporate knowledge management, etc.) and informal (e.g. recreational research, PIM, exploring exhaustive subject areas prior to formal exploration, etc.)" (Macgregor and McCulloch, 2006)

Like tagging systems, recommender systems are concerned with the relationships between people and resources, and the extent to which these connections can be leveraged to help users find new resources and people they would otherwise miss (Marlow, et al., 2006). To this extent, content tagging systems could be seen as complementary to recommender systems, as tags are the primary means of finding similar resources. Some have stipulated that these two systems would marry well, "feeding each other with recommended content" (Marlow, et al., 2006).

Finally, it is important to note that user interface design considerations and user incentives can have a major influence on the usefulness of information in both systems, and in a reciprocal fashion, on how users appropriate and utilize these systems. Because the effectiveness of both content tagging and recommender systems increases as user participation increases, both systems must be designed to inspire user contributions. The design of the system may make tagging or recommender systems useful for discovery, retrieval, remembrance, social interaction, or possibly, all of the above (Marlow, et al., 2006)

APPENDIX A: DEFINITION OF TERMS

Administrative Metadata

Provides information to help manage a resource, such as when and how it was created, file type and other technical information, and who can access it. . (NISO, 2004)

Ambient Findability

Ambient findability describes a fast emerging world where we can find anyone or anything from anywhere at anytime. Findability is a quality that can be measured at both the object and system levels. It is the quality of being locatable or navigable, the degree to which a particular object is easy to discover or locate, and the degree to which a system or environment supports navigation and retrieval. (Morville, 2005)

Ambiguous Organization Schemes

Unlike exact organization schemes that seek to divide information into well-defined and mutually exclusive categories, ambiguous organization schemes classify information in multiple ways and categories depending on its context and meaning at the time of categorization. Ambiguous organization facilitates serendipitous information discovery by grouping items in contextually relevant ways. The grouping patterns of ambiguous organization schemes support associative learning that enables users to identify new and unintended relationships about the information they are seeking (Morville and Rosenfeld, 2002).

Collaborative Classification

The process of classifying data with uncontrolled key word terms provided by individuals of a group. (Fu, et al., 2006).

Collaborative filtering

A technological method of filtering user preferences to find a match with others of a group. Collaborative filtering systems can produce personal recommendations by computing the similarity of preferences. (Good et al., 1999)

Collaborative Information Sharing

Information that is created, distributed, and accessed in virtual, electronic communities through forms of overt human cooperation (Bielenberg & Zacher, 2005).

Content Management System

A Content Management System allows content to be stored, retrieved, edited, updated, controlled, and then output in a variety of ways such that the incremental cost of each update cycle and output production shrinks dramatically over time (Kartchner, 1998). It facilitates the organization, control, and publication of a large body of documents and other content, such as images and multimedia resources. A content management system can also facilitate the collaborative creation of documents.

Content Tagging

The process of applying key work terms or descriptions to classify content in order to locate it at later time. For purposes of this study, content tagging is enabled through the use of a web-based tool designed to capture this user-generated metadata. Content tagging is typically a component of web-based social software, and is the key functionality required for a folksonomy. Content tagging is an interaction between humans, terms and objects over time which results in a collectively organized knowledge. (Golder and Huberman, 2006).

Content Tagging Systems

Web-based information systems that enable users to assign uncontrolled keywords to information resources. Such tags are used to enable the organization of information within a personal information space, but are also shared, thus allowing the browsing and searching of tags attached to information resources by other users. It also allows users to tag their information resources with those tags that exemplify popularity. Tags are generally single terms, however the assignation of multiple tags to a single resource can be accommodated by omitting essential syntax or punctuation and by using symbols to combine terms (e.g. information+management) (Macgregor and McCulloch, 2006).

Contextually Relevant Information

Information that has meaning based on its relationship to other components of an information system such as other information, its usage or application, or user defined meaning of the information (Bailey, 1997).

Controlled Vocabulary

A list of terms that have been explicitly selected and managed by individual or team-based content management authorities used to classify, categorize, and reference information. All terms in a controlled vocabulary have an unambiguous, non-redundant definition (Warner, 2006).

Descriptive Metadata

Describes a resource for purposes such as discovery and identification. It can include elements such as title, abstract, author, and keywords. (NISO, 2004)

Findability

For purposes of this study, findability refers to the likelihood of retrieving desired information in a web-based system. Findability refers to the quality of being locatable or navigable. At the item level, we can evaluate to what degree a particular object is easy to discover or locate. At the system level, we can analyze how well a physical or digital environment supports navigation and retrieval. Information that is highly findable is easily located and accessed through the use of a well developed information retrieval system (Morville, 2005).

Folksonomy

A contraction of the words folk and taxonomy, it is a method of classifying information in a collaborative and decentralized way by soliciting user-generated metadata in the form of key-word “tags” to be used as part of a bottom-up consensus building process (Mathes, 2004)**.** It is a collaborative classification tool designed to enable individuals to tag content with key terms that are meaningful to them and to view terms of other users that aid in information discovery and retrieval. In a folksonomy, participants classify information according to their own point of view and agree to share their classification with the other users (Dye, 2006).

Information Artifact

An item that contains information in a digital, web-based domain that can be located, retrieved, and deliver value such as a web page, document, graphic, audio, or video file. (Kimball, 1998).

Information Classification

The process of grouping information into intuitive categories by applying descriptive metadata that may be used as part of an organization schema designed to aid information retrieval and discovery (Mathes, 2004).

Information Discovery

The process of retrieving useful information through serendipitous means (Morville and Rosenfeld, 2002) – often due to classification descriptions provided by other users in ambiguous organization systems such as folksonomies (Mathes, 2004).

Information Retrieval

The process of locating desired information through the use of web based search utilities (Morville, 2004).

Information System

A web-based information system consists of organization, labeling, navigation, and searching sub-systems that help people find and manage information more successfully (Morville & Rosenfeld, 2002).

Interaction Design

A professional discipline within the broader field of user experience design focused on the design of the user interface for digital content. It is typically a multi-disciplinary role drawing from the fields of visual design, information architecture, and human-factors engineering. The core role of an interaction designer is to define the behavior of artifacts, environments, and systems (i.e., products) as they relate to their behavior and use (Reimann, 2001).

Learnability

A measure of the degree to which a user interface can be learned quickly and effectively. Learning time is the typical measure. User interfaces are typically easier to learn when they are designed to be easy to use based on core cognitive properties, and when they are familiar. Familiarity may come from the fact that it follows standards or that the design follows a metaphor from people's real world experience (Design Council, 2006).

Metadata

Structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource. Metadata is often called data about data or information about information (NISO, 2004).

Ranking and Rating Tools

In recommender systems, content ranking and rating tools collect user-generated metadata in the form of opinions to measure individual satisfaction of a specific information artifact (product, person, idea, etc.). Collaborative filtering software often combines overt, explicit user ratings with implicit observations of user behavior and decision making to generate recommendations (Basu, Hirsh, and Cohen, 1998).

Recommender Systems

Recommender systems capture implicit and explicit user decisions and behavior in order to recommend content that matches previous choices. This study focuses on explicit user-generated actions such as content rating/ranking that provide personal metadata about the item being acted upon. Most recommender systems rely on collaborative filtering software that leverage algorithmic models to generate predictive recommendations. Recommender systems use the opinions of a community of users to help individuals in that community more effectively identify content of interest from a potentially overwhelming set of choices (Resnick & Varian, 1997).

Search System

One of 4 key information architecture components in a web-based information system (the other three being the organization system, labeling system, and navigation system) (Morville and Rosenfeld, 2002) designed to support information location and retrieval in web-based contexts. The search system provides the tools and presentation of results that enable users to locate desired information in complex information systems (Morville and Rosenfeld, 2002).

Serendipitous Information Discovery

In search systems, serendipitous discovery is the process of retrieving information related to an initial search query due to the presentation of related information in the search results. This occurs most often in ambiguous classification schemes where information is likely to exist in multiple categories depending on the context of the search. The grouping patterns of ambiguous organization schemes support associative learning that enables users to identify new and unintended relationships about the information they are seeking (Morville and Rosenfeld, 2002).

Social Computing

Social computing is the use of social software to create social conventions and contexts in a virtual, web-based community (Millen and Patterson, 2002).

Social Software

Tools (software) designed to enable peer-to-peer interactions in order to facilitate content creation and collaboration through computer-mediated communication. It enables a “bottom-up” approach where users of the software create the system’s value rather than the value being delivered by an external source (Tepper, 2003).

Structural Metadata

Indicates how compound objects are put together, for example, how pages are ordered to form chapters. (NISO, 2004)

Unstructured User-Generated Metadata

Metadata that is created in a "bottom-up" method by users of a social software system. It is unstructured because it is not predefined by a formal content management system using a controlled vocabulary, taxonomy, ontology, or other structured categorization process (Mathes, 2004).

User-Defined Metadata

Metadata that is defined and described by human users based on individual preferences rather than by structured content classification or management requirements such as taxonomies or controlled vocabularies (Golder and Huberman, 2005).

User Experience Design

User Experience Design is a professional field of practice that encompasses traditional Human-Computer Interaction (HCI) design and extends it by addressing all aspects of a product or service as perceived by users. User Experience Design addresses the user's initial awareness, discovery, ordering, fulfillment, installation, service, support, upgrades, and end-of-life activities. While User Experience Design includes the human-computer interface, it is about designing the total user experience, which consists of all aspects of a product or service as perceived by users (IBM, 2006).

APPENDIX B: SOURCES SELECTED FOR CONTENT ANALYSIS

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APPENDIX C: KEY PASSAGES REFERENCED

S-CT-IC

Real-time/immediate classification results and system feedback

(Millen, Feinberg, and Kerr, 2005)
(Golder and Huberman, 2005)
(Mathes, 2004)
(Bielenberg and Zacher, 2005)
(Macgregor and McCulloch, 2006)
(Fox, 2006)

“The possibility of choosing a free text description for tagging a resource has also advantages from a usability perspective. People do not have to browse through long keyword lists to look for matching categories or sub-categories. Tagging resources with keywords is a common practice, not only in folksonomies. The difference to previously existing systems is that after assigning a tag to a resource other resources labeled with the same tag are displayed - this way implementing ***a tight feedback loop*** [Udell2004]. “(Bielenberg and Zacher, 2005)

“Collaborative tagging utilises existing cognitive processes without adding to the cognitive load experienced by the user. She [Shina] proposes a rudimentary cognitive model of the tagging process and highlights the ability of ***immediate tagging feedback*** to circumvent the condition of so-called ‘post activation analysis paralysis’. According to Sinha, such a condition places the user in a state of cognitive paralysis and is triggered when he/she attempts to tag an information resource to ensure future re-findability. Sinha suggests that collaborative tagging reduces the cognitive load experienced by the user because the intellectually onerous task of deciding how a particular resource should be tagged is removed by using system feedback and by observing how others have tagged similar items.” (Macgregor and McCulloch, 2006)

“Tagging has more than just its ease of use to thank for its popularity; it’s also a powerful tool for making connections between assets, and ***its effects are easy to see immediately***. Adding keywords to content assets in the traditional way often feels like working in a black box. Big, enterprise-level content management systems are often involved, and it can be hard to see the direct result of the classification.” (Bielenberg and Zacher, 2005)

“For example, adding metadata can improve search, but the algorithms that Google and Yahoo! use have become so complex, and keywords are such a small factor in determining relevance, they often don’t seem to have much of an impact. Certainly there is rarely an immediate effect: Assuming keywords do make a difference, it can still take weeks or even months for a webpage to see improved rankings in web search engine results. It’s hard to see the direct effect of applying keywords in search results. But ***with tagging, the results are instantaneous***. Tags are also a navigational tool: On LiveJournal, users can move among the posts of all their friends based solely upon the tags those friends have applied. Certain circles even feel peer pressure to not only tag their items, but to come up with the most creative tags possible.” (Fox, 2006)

“The degree to which these systems bind the assignment of tags to their use - in a tight feedback loop - is that kind of difference. ***Feedback is immediate.*** As soon as you assign a tag to an item, you see the cluster of items carrying the same tag. If that’s not what you expected, you’re given incentive to change the tag or add another. This tight feedback loop leads to a form of asymmetrical communication between users through metadata.” (Mathes, 2004)

Creates Incentive for user classification/participation
(Dye, 2006)
(Golder and Huberman, 2005)
(Mathes, 2004)
(Bielenberg and Zacher, 2005)

"Systems employing free-form tagging that are encouraging users to organize information in their own ways are supremely responsive to user needs and vocabularies, and ***involve the users of information actively in the organizational system***. Overall, transforming the creation of explicit metadata for resources from an isolated, professional activity into a shared, communicative activity by users is an important development (Mathes, 2004)

"User behaviors are largely dictated by the forms of contribution allowed and the personal and social motivations for adding input to the system. ***Incentives and motivations for users*** also play a significant role in affecting the tags that emerge from social tagging systems. Users are motivated both by personal needs and sociable interests. The motivations of some users stem from a prescribed purpose, while other users consciously repurpose available systems to meet their own needs or desires, and still others seek to contribute to a collective process. A large part of the motivations and influences of tagging system users is determined by the system design and the method by which they are exposed to inherent tagging practices." (Marlow, et al., 2006)

Low cognitive barrier to entry and participation
(Bielenberg and Zacher, 2005)
(Macgregor and McCulloch, 2006)
(Mathes, 2004)
(Campbell and Fast, 2006)
(Golder and Huberman, 2005)

"She [Sinha] argues that collaborative tagging utilises existing cognitive processes without adding to the cognitive load experienced by the user. She proposes a rudimentary cognitive model of the tagging process and highlights the ability of immediate tagging feedback…Sinha suggests that ***collaborative tagging reduces the cognitive load experienced by the user*** because the intellectually onerous task of deciding how a particular resource should be tagged is removed by using system feedback and by observing how others have tagged similar items. (Macgregor and McCulloch, 2006)

"Reflecting ***the cognitive aspect of hierarchy and categorization***, the "basic level" problem is that related terms that describe an item vary along a continuum of specificity ranging from very general to very specific; as discussed above, cat, cheetah and animal are all reasonable ways to describe a particular entity. The problem lies in the fact that different people may consider terms at different levels of specificity to be most useful or appropriate for describing the item in question. Experiments demonstrate that, when asked to identify dogs and birds, subjects used "dog" and "bird" more than "beagle" or "robin," and when asked whether an item in a picture is an X, subjects responded more quickly when X was a "basic" level (Tanaka & Taylor 1991). These experiments demonstrate general agreement across subjects." (Golder and Huberman, 2005)

"The overall costs for users of the system in terms of time and effort are far lower than systems that rely on complex hierarchal classification and categorization schemes. The conceptual shift from professional, designed, clearly defined categorization and classification schemes to an ad-hoc set of keywords enables users not just professionals without any training or previous knowledge to participate in the system immediately. Additionally, participating is far easier in terms of time, effort and ***cognitive costs***." (Mathes, 2004)

Cost effective system implementation and maintenance

(Mathes, 2004)
(Campbell and Fast, 2006)

“The creation of metadata has generally been approached in two ways: professional creation and author creation. In libraries and other organizations, creating metadata, primarily in the form of catalog records, has traditionally been the domain of dedicated professionals working with complex, detailed rule sets and vocabularies. The primary problem with this approach is scalability and its impracticality for the vast amounts of content being produced and used, especially on the World Wide Web. While professionally created metadata are often considered of high quality, it ***is costly in terms of time and effort to produce***. This makes it very difficult to scale and keep up with the vast amounts of new content being produced, especially in new mediums like the World Wide Web. The apparatus and tools built around professional Cataloging systems are generally too complicated for anyone without specialized training and knowledge.” (Mathes, 2004)

Utilizes human classification methods

(Bielenberg and Zacher, 2005)
(Millen, Feinberg, and Kerr, 2005)
(Mathes, 2004)

“But instead of analyzing the semantic meaning of a search request, most often, search engines simply perform a syntax based pattern matching between the search string and all indexed resources ignoring any semantics. Automatic evaluation of a resource's semantic meaning is exceptionally difficult. Thus, ***reliable semantics have to be provided manually***. Metadata creation on a broad level is a precondition for semantic based information retrieval.” (Bielenberg and Zacher, 2005)

“***Folksonomies allow a person to choose a keyword freely*** for describing a resource in a way that makes sense to her. Instead of enforcing a controlled vocabulary a "vocabulary of users" [Mathes2004] evolves. This may lead to categories a professional taxonomy designer never would have thought of.” (Bielenberg and Zacher, 2005)

Scalable, flexible, and adaptive design

(Macgregor and McCulloch, 2006)
(Dye, 2006)
(Mathes, 2004)
(Golder and Huberman, 2005)

“While professionally created metadata are often considered of high quality, it is costly in terms of time and effort to produce. This makes it [taxonomy] ***very difficult to scale*** and keep up with the vast amounts of new content being produced, especially in new mediums like the World Wide Web.” (Mathes, 2004)

“As a top-down system, taxonomies rely heavily on centralized control of the structure and vocabulary, since findability hinges on uniform classification. Feeds, blogs, or any of the other ways to stream content virtually—***needs a more flexible categorization that can quickly adapt*** to change. Folksonomy "is built from the ground up by real users.” (Dye, 2006)

“Both tagging systems and taxonomies are beset by many problems that exist as a result of the necessarily imperfect, yet natural and ***evolving process of creating semantic relations between words and their referents.***” (Golder and Huberman, 2005)

“If your resource does not fit in a cluster thematically you will probably change the assigned tags. Mathes calls this process "**asymmetrical communication between users through metadata**" The ongoing success of folksonomies originates largely from the easy creation process of tags and the direct feedback of related items.” (Bielenberg and Zacher, 2005)

Open, social, and inclusive method of classifying information
(Macgregor and McCulloch, 2006)
(Mathes, 2004)
(Bielenberg and Zacher, 2005)
(Dye, 2006)

"Social tagging systems may afford multiple added benefits. For instance, a shared pool of tagged resources ***enhances the metadata for all users***, potentially distributing the workload for metadata creation amongst many contributors." (Mathes, 2004)

"Allows users to tag their own content so that ***they can easily retrieve it and help others find it***. Although narrow folksonomies and resulting tags lack the social cohesion of broad folksonomies, they are incredibly useful for assigning pertinent metadata to content that would otherwise confuse automated searchbots—like pictures, which contain no text for robots to interpret." (Dye, 2006)

Content may belong to multiple categories for broader classification
(Millen, Feinberg, and Kerr, 2005)
(Mathes, 2004)

"A second, and significant, enhancement in these systems is the use of keywords, or tags, that are explicitly entered by the user for each bookmark. These tags allow the individual user to organize and display the collection with meaningful labels. Furthermore, ***multiple tags allow bookmarks to belong to more than one category."*** (Millen, Feinberg, and Kerr, 2005)

"Categorization metadata is of special interest because it is not only descriptive - a category is a semantic description - but also structural ***relating similar categorized resources to one another***" (Bielenberg and Zacher, 2005)

Captures evolving vocabulary/terminology adaptations of topics/users/community
(Mathes, 2004)
(Bielenberg and Zacher, 2005)
(Golder and Huberman, 2005)

"Establishes desire lines***, accommodates organic vocabulary changes, and supports unique user vocabulary/specialized terminology/jargon"*** (Mathes, 2004)

"Perhaps the most important strength of a folksonomy is that it ***directly reflects the vocabulary of users***. The users of a system are negotiating the meaning of the terms in the folksonomy, whether purposefully or not, through their individual choices of tags to describe documents for themselves. In this way, it directly reflects their choices in diction, terminology, and precision…A folksonomy, with its uncontrolled nature and organic growth, has the ***capability o adapt very quickly to user vocabulary changes and needs***." (Mathes, 2004)

In Ambient Findability (2005), Morville uses pace layering to suggest that user-centered tagging systems can supplement traditional IA practices, rather than replacing them. Morville argues that user tagging, in all its messiness, speed and vitality, constitutes a fast layer of information architecture, one which ***will gradually affect the underlying structures of websites, which change and slower and more controlled rates:*** "over time, the lessons learned at the top are passed down, embedded into the more enduring layers of social and semantic infrastructure" (Morville 2005).

The spectrum of tags that folksonomy generates can be a fascinating indicator of not just how people individually interpret content, but also ***how that content evolves over time***. (Dye, 2006)

Accommodates both common and rare classification terms and stabilizes with the most common terms

(Golder and Huberman, 2005)
(Mathes, 2004)

"The combined tags of many users' bookmarks give rise to a stable pattern in which the proportions of each tag are nearly fixed. This stability has important implications for the collective usefulness of individual tagging behavior. After a relatively small number of bookmarks, a nascent consensus seems to form, one that is not affected by the addition of further tags. The commonly used tags, which are more general, have higher proportions, and the varied, personally oriented tags that users may use can coexist with them. Part of the reason these stable patterns emerge is that the ideas and characteristics that are represented in tags are stable. As the ideas themselves change, these stable states may likewise change. Nevertheless, ***because stable patterns emerge in tag proportions, minority opinions can coexist alongside extremely popular ones without disrupting the nearly stable consensus choices made by many users."*** (Golder and Huberman, 2005)

" [The folksonomy] Del.icio.us takes things a step further by employing a type-ahead feature that suggests similar tags a user might be interested in using. This not only helps people who have trouble deciding on which terms to use, but it also ***brings about some level of standardization among all the terms,*** the lack of which being one of the biggest criticisms of folksonomies" (Mathes, 2004)

"Those tags that are generally meaningful will likely be used by many taggers, while tags with personal or specialized meaning will likely be used by fewer users." (Golder and Huberman, 2005)

"it [tagging] follows a power law scenario. That is, ***the most used tags are more likely to be used by other users*** since they are more likely to be seen, and thus there will be a few tags that are used by a substantial number of users" (Mathes, 2004)

W-CT-IC

Lacks controlled classification and hierarchical structure of taxonomies

(Macgregor and McCulloch, 2006)
(Mathes, 2004)
(Campbell and Fast, 2006)

"By controlling the indexing process using a so-***called controlled vocabulary, index terms are standardised and similar or related resources*** are collocated for ease of discovery by the user...Although similar to an authority list, a controlled vocabulary differs in that it generally incorporates some form of ***semantic and hierarchical structure*** (Lancaster, 2003). This structure - and the control exerted over vocabulary - performs several functions: It controls lexical anomalies by minimising any superfluous vocabulary or grammatical variations that could potentially create further noise in the users' results set. It unites similar terms, or systematically refers the indexer to closely related alternatives, in order to ensure that similar or related resources are collocated." (Macgregor and McCulloch, 2006)

"The collaborative and ad hoc nature of tagging systems dictates that they lack the essential properties characterising controlled vocabularies (as defined earlier). ***No control is exerted in collaborative tagging***

systems over synonyms or near synonyms, homonyms and homographs, and the numerous lexical anomalies that can emerge in an uncontrolled environment.” (Macgregor and McCulloch, 2006)

“The ambiguity of individual tags or labels is directly related to the quality of categories. Tags may be interpreted differently from the creator's original intention outside of the creator's background. ***Unlike taxonomies there is no hierarchy*** that gives information about superior categories, for example to distinguish synonyms (think of the super category "fruits" or "computer" for the category "apple"). And finally tags may simply be wrong.” (Bielenberg and Zacher, 2005)

Lacks synonym and homonym controls

(Macgregor and McCulloch, 2006)
(Mathes, 2004)
(Bielenberg and Zacher, 2005)

“Synonymy, or multiple words having the same or closely related meanings, presents a greater problem for tagging systems because ***inconsistency among the terms used in tagging can make it very difficult for one to be sure that all the relevant items have been found***. This problem is compounded in a collaborative system, where all taggers either need to widely agree on a convention, or else accept that they must issue multiple or more complex queries to cover many possibilities. Synonymy is a significant problem because it is impossible to know how many items “out there” one would have liked one’s query to have retrieved, but didn’t.” (Golder and Huberman, 2005)

“The ambiguity of individual tags or labels is directly related to the quality of categories. Tags may be interpreted differently from the creator's original intention outside of the creator's background. Unlike taxonomies there is no hierarchy that gives information about superior categories, for example ***to distinguish synonyms*** (think of the super category "fruits" or "computer" for the category "apple"). And finally tags may simply be wrong.” (Bielenberg and Zacher, 2005)

Requires large population of classifiers for useful results

(Dye, 2006)
(Mathes, 2004)
(Marlow, et al., 2006)
(Campbell and Fast, 2006)

The collective wisdom of the tagging community is only as reliable as its members. " (Dye, 2006)

While tagging has the potential to be valuable for numerous applications, users can be unaware of or uninterested in the broader design motivations. Since user incentives are influenced by the design of a given system, the motivations underlying tagging vary both by people and by systems. Some users begin to appreciate the sociable aspects over time, ***while others have no interest in that component -or intention of contributing to the greater good***. (Marlow, et al., 2006)

“At the heart of folksonomy efforts lies a set of assumptions that have long held enormous cachet in Web circles, at least since Google’s PageRank revolutionized search engine performance:
• If you get enough people doing what they like—linking, tagging, sharing or subscribing—interesting and useful patterns emerge. ***These patterns get more useful and more interesting as more people join in***

to do what they like;
• Systems that exploit these patterns can scale to larger sizes in ways that traditional information systems, such as library catalogues, cannot;
• Systems with fewer rules and constraints are more likely to obtain widespread adoption and more likely to generate beneficial emergent patterns." (Campbell and Fast, 2006)

Allows for term ambiguity – spelling errors, multiple words used for a single tag description, personal notes "todo" "toread" etc

(Mathes, 2004)
(Bielenberg and Zacher, 2005)
(Dye, 2006)

"The probability of noise in a user's result set is therefore very high. The corollary dictates that this impacts negatively upon retrieval precision, as well as limiting the ability to collocate similar or related resources. The ***inconsistent and ambiguous assignation of tags, and the user proclivity towards exhaustive tags (e.g. 'marketing', 'technology', etc.), popular tags and personal tags (e.g. 'me', 'toread', etc.) further compromises precision*** and contributes to high levels of recall and noise also." (Macgregor and McCulloch, 2006)

"[A classification problem] occurs when multiple words are used together in a single tag, without spaces." (Mathes, 2004)

"The ***ambiguity of individual tags or labels is directly related to the quality of categories***. Tags may be interpreted differently from the creator's original intention outside of the creator's background. Unlike taxonomies there is no hierarchy that gives information about superior categories…" (Bielenberg and Zacher, 2005)

No professional oversight to manage classification standards

(Golder and Huberman, 2005)

Expertise plays a role in defining what level of specificity an individual treats as "basic." Like variation in expertise, variations in other social or cultural categories likely yield variations in basic levels. (Golder and Huberman, 2005)

Classification choices influences by existing tags

(Cosley, et al., 2003),

Showing information about an item at the time a user rates it might affect the user's opinion, leading to three potential problems. First, the altered opinion might provide the recommender with ***less accurate preference information***, leading to ***less accurate predictions*** in the future. Second, the altered opinions might ***make it hard to evaluate the quality of a system's recommendations.*** Third, unscrupulous agents might take advantage of this effect to amplify false opinions they inject into the system. Such ***opinions might be artificially inflated***, leading to unusually positive recommendations which may in turn induce unusually positive ratings from other users. (Cosley, et al., 2003)

S-CT-IR

Common, “Basic Level” categorization patterns emerge

(Golder and Huberman, 2005)

Reflecting the cognitive aspect of hierarchy and categorization, the “**basic level**” problem is that related terms that describe an item vary along a continuum of specificity ranging from very general to very specific; as discussed above, cat, cheetah and animal are all reasonable ways to describe a particular entity. The problem lies in the fact ***that different people may consider terms at different levels of specificity to be most useful or appropriate for describing the item in question***. ***The “basic level,” as opposed to superordinate (more general) and subordinate (more specific) levels, is that which is most directly related to humans’ interactions with them*** (Tanaka & Taylor 1991). For most people, the basic level for felines would be “cat,” rather than “animal” or “Siamese” or “Persian.” Experiments demonstrate that, when asked to identify dogs and birds, subjects used “dog” and “bird” more than “beagle” or “robin,” and when asked whether an item in a picture is an X, subjects responded more quickly when X was a “basic” level (Tanaka & Taylor 1991). These experiments demonstrate general agreement across subjects. (Golder and Huberman, 2005)

the earlier tags in a bookmark represent basic levels, because they are not only widespread in agreement, but are also ***the first terms that users thought of when tagging*** the URLs in question.- The "Basic Level Problem" (Golder and Huberman, 2005)

Homonyms can be largely ruled out in a tag-based search through the addition of a related term with which the unwanted homonym would not appear. (Golder and Huberman, 2005)

Tag terms “stabilize” and common terms emerge

(Golder and Huberman, 2005)
(Mathes, 2004)

It turns out that the combined tags of many users’ bookmarks give rise to a stable pattern in which the proportions of each tag are nearly fixed. Empirically, we found that, usually after the first 100 or so bookmarks, each tag’s frequency is a nearly fixed proportion of the total frequency of all tags used. This stability has important implications for the collective usefulness of individual tagging behavior. After a relatively small number of bookmarks***, a nascent consensus seems to form, one that is not affected by the addition of further tags. The commonly used tags, which are more general, have higher proportions, and the varied, personally oriented tags that users may use can coexist with them.*** Two reasons why this stabilization might occur are imitation and shared knowledge. The Delicious interface through which users add bookmarks shows users the tags most commonly used by others who bookmarked that URL already; users can easily select those tags for use in their own bookmarks, thus imitating the choices of previous users. Accordingly, some documents may occupy roughly the same status in many of those users’ lives; since they may make use of web documents in the same way, users may categorize them the same way, as well. Part of the reason these stable patterns emerge is that the ideas and characteristics that are represented in tags are stable. As the ideas themselves change, these stable states may likewise change. Nevertheless, because stable patterns emerge in tag proportions, minority opinions can coexist alongside extremely popular ones without disrupting the nearly stable consensus choices made by many users. (Golder and Huberman, 2005)

Perhaps the most important strength of a folksonomy is that it directly reflects the vocabulary of users. In an information retrieval system, there are at least two, and possibly many more vocabularies present (Buckland, 1999). These could include that of the user of the system, the designer of the system, the author of the material, the creators of the classification scheme; translating between these vocabularies is often a difficult and defining issue in information systems. The users of a system are negotiating the meaning of the terms in the folksonomy, whether purposefully or not, through their individual choices of tags to describe documents for themselves. As discussed earlier, a folksonomy represents a fundamental shift in that it is derived not from professionals or content creators, but from the users of information and documents. In this way, it directly reflects their choices in diction, terminology, and precision. Once you have a preliminary system in place, you can use the most common tags to develop a controlled vocabulary that truly speaks the users' language." A folksonomy, with its uncontrolled nature and organic growth, has the capability to adapt very quickly to user vocabulary changes and needs. There is no significant cost for a user or for the system to add new terms to the folksonomy. (Mathes, 2004)

Access to specialized or trusted content through tag pattern visibility

(Mathes, 2004)
(Marlow, et al., 2006)
(Golder and Huberman, 2005)

For the reasons described above, ***those tags that are generally meaningful will likely be used by many taggers***, while tags with personal or specialized meaning will likely be used by fewer users. (Golder and Huberman, 2005)

Access to information discovery and serendipitous finding

(Marlow, et al., 2006)
(Mathes, 2004)
(Bates, 1998)
(Macgregor and McCulloch, 2006)

Collaborative tagging can prove beneficial for users' search strategies, providing an increased number of entry points and a measure of serendipity unattainable using controlled vocabularies. Mathes postulates that the serendipitous nature of collaborative tagging, although not necessarily conducive to known-item retrieval or goal-directed browsing, complements non-goal-directed searching and browsing by introducing the user to potentially invaluable resources that would otherwise have been undiscoverable. (Macgregor and McCulloch, 2006)

So throughout the process of information retrieval evaluation under the classic model, the query is treated as a single unitary, one-time conception of the problem. Though this assumption is useful for simplifying IR system research, real-life searches frequently do not work this way. In real-life searches in manual sources, end users may begin with just one feature of a broader topic, or just one relevant reference, and move through a variety of sources. Each new piece of information they encounter gives them new ideas and directions to follow and, consequently, a new conception of the query. At each stage they are not just modifying the search terms used in order to get a better match for a single query. Rather the query itself (as well as the search terms used) is continually shifting, in part or whole. This type of search is here called an evolving search. (Bates, 1998)

Provides precision and recall simultaneously

(Mathes, 2004)
(Golder and Huberman, 2005)
(Marlow, et al., 2006)
(Macgregor and McCulloch, 2006)

There are positive lessons to be learned from the interactivity and social aspects exemplified by collaborative tagging systems. Even if their utility for high precision information retrieval is minimal, they succeed in engaging users with information and online communities, and prove useful within PIM contexts. The need to engage users in the development of controlled vocabularies has been recognised by vocabulary experts (Abbott, 2004; Mai, 2004) and collaborative tagging systems could potentially provide a base model for such approaches. Ultimately the dichotomous co-existence of controlled vocabularies and collaborative tagging systems will emerge; with each appropriate for use within distinct information contexts: formal
(e.g. academic tasks, industrial research, corporate knowledge management, etc.) and informal (e.g. recreational research, PIM, exploring exhaustive subject areas prior to formal exploration, etc.). (Macgregor and McCulloch, 2006)

W-CT-IR

Lack of precision and increase in “noise”

(Macgregor and McCulloch, 2006)

The collaborative and ad hoc nature of tagging systems dictates that they lack the essential properties characterising controlled vocabularies (as defined earlier). No control is exerted in collaborative tagging systems over synonyms or near synonyms, homonyms and homographs, and the numerous lexical anomalies that can emerge in an uncontrolled environment. The probability of noise in a user's result set is therefore very high. The corollary dictates that this impacts negatively upon retrieval precision, as well as limiting the ability to collocate similar or related resources. The inconsistent and ambiguous assignation of tags, and the user proclivity towards exhaustive tags (e.g. ‘marketing’, ‘technology’, etc.), popular tags and personal tags (e.g. 'me', 'toread', etc.) further compromises precision and contributes to high levels of recall and noise also. (Macgregor and McCulloch, 2006)

The problem is that while the disparate user vocabularies and terms enable some very interesting browsing and finding, the sheer multiplicity of terms and vocabularies may overwhelm the content with noisy metadata that is not useful or relevant to a user. (Mathes, 2004)

Results may be manipulated through unscrupulous classification (tagging) methods

(Cosley, et al., 20030

Further, manipulators who seek to make the system generate artificially high or low recommendations might benefit if their efforts influence users to change the opinions they contribute to the recommender. (Cosley, et al., 20030

Breadth of recall (related tags) may be overwhelming (cognitive noise)

(Dye, 2006)
(Golder and Huberman, 2005)
(Mathes, 2004)
(Macgregor and McCulloch, 2006)
(Campbell and Fast, 2006)

Its uncontrolled nature is fundamentally chaotic, suffers from problems of imprecision and ambiguity that well developed controlled vocabularies and name authorities effectively ameliorate. (Mathes, 2004)

There are numerous difficulties with collaborative tagging systems (e.g. low precision, lack of collocation, etc.) that originate from the absence of properties that characterise controlled vocabularies. (Macgregor and McCulloch, 2006)

The collaborative and ad hoc nature of tagging systems dictates that they lack the essential properties characterising controlled vocabularies (as defined earlier). No control is exerted in collaborative tagging systems over synonyms or near synonyms, homonyms and homographs, and the numerous lexical anomalies that can emerge in an uncontrolled environment. The probability of noise in a user's result set is therefore very high. The corollary dictates that this impacts negatively upon retrieval precision, as well as limiting the ability to collocate similar or related resources. The inconsistent and ambiguous assignation of tags, and the user proclivity towards exhaustive tags (e.g. 'marketing', 'technology', etc.), popular tags and personal tags (e.g. 'me', 'toread', etc.) further compromises precision and contributes to high levels of recall and noise also. (Macgregor and McCulloch, 2006)

S-CT-ID

Multiple entry/pivot points to related content

(Macgregor and McCulloch, 2006)
(Mathes, 2004)
(Marlow, et al., 2006)
(Millen, Feinberg, and Kerr, 2005)

There is a bias toward increased transparency in these tools. Although [tag] collections are personally created and maintained, they are typically visible to others. A number of user interface elements allow social browsing of the [tag] space. For example, user names are "clickable" links; clicking on a name reveals the collection for that user. This allows someone to get a sense of the topics of interest for a particular user. Similarly, tags are also clickable, and when selected will result in a list of [content elements] that share that tag. This is a useful way to browse through the entire collection to see if it includes information sources of interest. The ability to reorient the view by clicking on tags or user names, called **pivot browsing**, provides a lightweight mechanism to navigate the aggregated tag collection. (Millen, Feinberg, and Kerr, 2005)

browsing the system and its interlinked related tag sets is wonderful for ***finding things unexpectedly*** in a general area. (Mathes, 2004)

Locate other users/groups with related interests and content – Aids Community building/social networks

(Marlow, et al., 2006)
(Mathes, 2004)
(Schafer, Konstan, and Reidl, 2001)
(Bielenberg and Zacher, 2005)

The degree to which these systems bind the assignment of tags to their use - in a tight feedback loop - is that kind of difference. Feedback is immediate. As soon as you assign a tag to an item, you see the cluster of items carrying the same tag. If that's not what you expected, ***you're given incentive to change the tag or add another. This tight feedback loop leads to a form of asymmetrical communication between users through metadata***. (Mathes, 2004)

Therefore the behavior of the users can also be thought of as being influenced and related to their relationship to the other individuals using the [tagging] service, and specific groups of users who they share tag use with. It is perhaps harder to justify this model simply from examination of the tags used, but there is ***definitely evidence of communication and perhaps even community formation through metadata...A folksonomy lowers the barriers to cooperation***. Groups of users do not have to agree on a hierarchy of tags or detailed taxonomy, they only need to agree, in a general sense, on the "meaning" of a tag enough to label similar material with terms for there to be cooperation and shared value. Although this may require a change in vocabulary for some users, it is never forced, and as Udell discussed, the tight feedback loop provides incentives for this cooperation. Delicious allows you to "subscribe" to other users lists. (Mathes, 2004)

Tags form communities. Or as Weinberger (2005) states: "Find people who tag items the same way as you do and you've now found a social group based not around shared interests but around shared ways of thinking and shared ways of speaking" [Weinberger2005]. (Bielenberg and Zacher, 2005)

Folksonomies are easy to use - adding freely chosen keywords can be done by anyone. Not only related information, ***but also people with a shared understanding can be identified***. (Bielenberg and Zacher, 2005)

Collaboration through collective tagging gives members of these communities a chance to build their own search systems from the ground up, based on their own vocabularies, interests, and ideas. Folksonomy sites use simple popularity (number of tags) to rank articles on their homepages, so users can easily ***sample what the rest of the community has.*** (Dye, 2006)

Community inputs include a broad range of data regarding how multiple individuals in the community, ***or the community as a whole, perceive items***. Inputs that reflect overall community opinions include item attribute assignments that assign community-based labels and categories to items. (Schafer, Konstan, and Reidl, 2001)

Exposure to related but unexpected content

(Macgregor and McCulloch, 2006)
(Mathes, 2004)
(Marlow, et al., 2006)

Establishes desire lines, accommodates organic vocabulary changes, and supports unique user vocabulary/specialized terminology/jargon (Mathes, 2004)

"Collaborative tagging can prove beneficial for users' search strategies, ***providing an increased number of entry points and a measure of serendipity unattainable using controlled vocabularies***. Mathes postulates that the serendipitous nature of collaborative tagging, although not necessarily conducive to known-item retrieval or goal-directed browsing, complements non-goal-directed searching and browsing by ***introducing the user to potentially invaluable resources that would otherwise have been undiscoverable***." (Macgregor and McCulloch, 2006)

When comparing how advice from friends and from RS is perceived, Swearingen and Sinha [4, 9] found that, while people overall preferred recommendations from their friends, they appreciated the ability of an RS to provide serendipitous recommendations that broadened their horizons. In that context, Swearingen and Sinha [5, 9] identified two factors as fundamentally important in the overall usefulness of an RS — familiar recommendations and system transparency. (Bonhard and Sasse, 2006)

Supports browsing – berrypicking – over searching

(Bates, 1998)

So throughout the process of information retrieval evaluation under the classic model, the query is treated as a single unitary, one-time conception of the problem. Though this assumption is useful for simplifying IR system research, real-life searches frequently do not work this way. In real-life searches in manual sources, end users may begin with just one feature of a broader topic, or just one relevant reference, and move through a variety of sources. Each new piece of information they encounter gives them new ideas and directions to follow and, consequently, a new conception of the query. At each stage they are not just modifying the search terms used in order to get a better match for a single query. Rather the query itself (as well as the search terms used) is continually shifting, in part or whole. This type of search is here called an evolving search. (Bates, 1998)

W-CT-ID

Competing grouping, categories, and terms

(Golder and Huberman, 2005)
(Mathes, 2004)
(Macgregor and McCulloch, 2006)

However, in practice, categories are often not well defined and their boundaries exhibit vagueness (Labov 1973). Items often lie between categories or equally well in multiple categories. The lines one ultimately draws for oneself reflect one's own experiences, daily practices, needs and concerns. (Golder and Huberman, 2005)

The problem is that while the disparate user vocabularies and terms enable some very interesting browsing and finding, the sheer multiplicity of terms and vocabularies may overwhelm the content with noisy metadata that is not useful or relevant to a user (Mathes, 2004)

Synonymy, or multiple words having the same or closely related meanings, presents a greater problem for tagging systems because inconsistency among the terms used in tagging can make it very difficult for one to be sure that all the relevant items have been found. This problem is compounded in a collaborative system, where all taggers either need to widely agree on a convention, or else accept that they must issue multiple or more complex queries to cover many possibilities. (Golder and Huberman, 2005)

There are numerous difficulties with collaborative tagging systems (e.g. low precision, lack of collocation, etc.) that originate from the absence of properties that characterise controlled vocabularies. (Macgregor and McCulloch, 2006)

Categories and terms are subjective

(Bielenberg and Zacher, 2005)
(Golder and Huberman, 2005)
(Mathes, 2004)

Retrieval of resources through categories is a subjective process depending on a person's background and her intentions. A strict taxonomy forces a person "to view the world in potentially unfamiliar ways" [Merholz2004], namely with the eyes of the taxonomy's creator. Nevertheless a taxonomy's hierarchical structure offers support for searching and browsing. In this respect folksonomies offer only marginal assistance. It is more a kind of serendipitous form of browsing." (Bielenberg and Zacher, 2005)

The ambiguity of individual tags or labels is directly related to the quality of categories. Tags may be interpreted differently from the creator's original intention outside of the creator's background. Reasons could be cultural differences, different knowledge domains or differing degrees of knowledge. Furthermore tags can be completely personal (like "toread") or only meaningful for people knowing the creator's background. Unlike taxonomies there is no hierarchy that gives information about superior categories, for example to distinguish synonyms (think of the super category "fruits" or "computer" for the category "apple"). And finally tags may simply be wrong. (Bielenberg and Zacher, 2005)

Collective tagging, then, has the potential to exacerbate the problems associated with the fuzziness of linguistic and cognitive boundaries. As all taggers' contributions collectively produce a larger classification system, that system consists of idiosyncratically personal categories as well as those that are widely agreed upon. (Golder and Huberman, 2005)

Ambiguity of the tags can emerge as users apply the same tag in different ways. At the opposite end of the spectrum, the lack of synonym control can lead to different tags being used for the same concept, precluding collocation. As an uncontrolled vocabulary that is shared across an entire system, the terms in a folksonomy have inherent ambiguity as different users apply terms to documents in different ways. There are no explicit systematic guidelines and no
scope notes. (Mathes, 2004)

Dependent on large community of users tagging content related to original search – scarcity problem.

(Bielenberg and Zacher, 2005)
(Dye, 2006)

The drawbacks of folksonomies are usually just the flip sides of their advantages. For instance, a rich variety of tags can give users a broad context for the search, but it can also limit the findability of a specific piece of information, which could be found under any of its tags. Tags are based on personal associations, but if the community's popular associations don't match up with yours — or their choices in spelling and punctuation aren't what you expect—then you might have difficulty finding what you need. (Dye, 2006)

the collective wisdom of the tagging community is only as reliable as its members. (Dye, 2006)

May lack expert or specialized results managed by domain experts

(Marlow, et al., 2006)
(Mathes, 2004)

By controlling the indexing process using a so-called controlled vocabulary, index terms are standardised and similar or related resources are collocated for ease of discovery by the user...Although similar to an authority list, a controlled vocabulary differs in that it generally incorporates some form of semantic and hierarchical structure (Lancaster, 2003). This structure - and the control exerted over vocabulary - performs several functions: It controls the use of synonyms (and near-synonyms) by establishing a single form of the term. It discriminates between homonyms, allowing the indexer to resolve clashes of meaning that arise when several terms assume the same form but assume distinct meanings. It controls lexical anomalies by minimising any superfluous vocabulary or grammatical variations that could potentially create further noise in the users' results set. it unites similar terms, or systematically refers the indexer to closely related alternatives, in order to ensure that similar or related resources are collocated. The structure also facilitates the use of codes or notation which can then be associated with terms. Such notation is mnemonic, predictable, and language independent (Macgregor and McCulloch, 2006)

S-RS-IC

Classification based on previous user behavior.

(Porter, 2006)
(Schafer, Konstan, and Reidl, 2001)
(Melville, Mooney, and Nagarajan, 2002)

"With recommendation systems, much of this organizational maintenance goes away. The users organize their own content, in a sense, as the system monitors their constant activity to decide what navigation options go where." (Porter, 2006)

"Recommender systems use product knowledge—either hand-coded knowledge provided by experts or "mined" knowledge learned from the behavior of consumers—to guide consumers through the often-overwhelming task of locating products they will like. The products can be recommended based on the top overall sellers on a site, on the demographics of the consumer, or on an analysis of the past buying behavior of the consumer as a prediction for future buying behavior." (Schafer, Konstan, and Reidl, 2001)

"Recommender systems help overcome information overload by providing personalized suggestions based on a history of a user's likes and dislikes. There are two prevalent approaches to building recommender systems — Collaborative Filtering (CF) and Content-based (CB) recommending. CF systems work by collecting user feedback in the form of ratings for items in a given domain and exploit similarities and differences among profiles of several users in determining how to recommend an item. On the other hand, content-based methods provide recommendations by comparing representations of content contained in an item to representations of content that interests the user." (Melville, Mooney, and Nagarajan, 2002)

Multiple classification methods applied (Implicit and explicit based)

(Adomavicius and Tuzhilin, 2005)
(Schafer, Konstan, and Reidl, 2001)

(Herlocker, et al., 2004)

The improvement over the traditional information retrieval approaches comes from the use of user profiles that contain information about users' tastes, preferences, and needs. The profiling information can be elicited from users explicitly, e.g., through questionnaires, or implicitly—learned from their transactional behavior over time. (Adomavicius and Tuzhilin, 2005)

RS systems should collect and combine both implicit and explicit information - We also recommend that evaluations combine explicit and implicit data collection whenever possible. This is important because user preferences and performance may diverge: users may prefer one system to another, even when their performance is the same on both, or vice versa. One advantage of gathering data about both performance and preferences is that the two can be correlated. (Herlocker, et al., 2004)

While many recommender applications are still global in nature, more are beginning to respond to the customer's current state by using the customer's current navigation to provide context for the production or refinement of recommendations. Consumer behaviors interpreted for this input include both actions the consumer would have performed in exactly the same way even if he was unaware of the recommender system, and actions the consumer performs for the sole purpose of enhancing the recommendations. Implicit navigation inputs are, generally, inferred from the customer's behavior without the customer's awareness of their use for recommendation processes. In contrast, explicit navigation inputs are intentionally made by the customer with the purpose of informing the recommender application of his or her preferences. To offer these, sites provide the customer with a finite set of attribute choices as navigational links. By navigating to a list of interest, the customer can get recommendations for products in a fairly specific category. Despite differences in the configuration of these systems, from a customer's point of view, he is simply navigating. (Schafer, Konstan, and Reidl, 2001)

Classifications built by multiple related (nearest neighbor) user choices

(Bonhard and Sasse, 2006)

Recommendations are generated for a given user by comparing their existing ratings to those of all other users in the database. In doing so, a neighborhood of similar users is established, and based on that, rating predictions are computed for items that users have not yet rated, but closest neighbors have. (Bonhard and Sasse, 2006)

W-RS-IC

Machine/algorithm-based – lacks contextual, human classification

(Adomavicius and Tuzhilin, 2005)
(Cosley, et al., 2003)
(Schafer, Konstan, and Reidl, 2001)

Difficult and expensive to design, configure, deploy, and maintain

(Porter, 2006)
(Cosley, et al., 2003)
(Schafer, Konstan, and Reidl, 2001)

Recommendation systems are intensive, database-driven applications that are not trivial to create and get running. It takes a serious development project to do so. Moving to a recommendation system takes time, energy, and a long-term commitment. (Porter, 2006)

Sometimes recommendations are wrong. In extreme cases recommendations can be offensive. For example, Wal-Mart got into serious hot water last year when its movie recommendation system recommended movies in an inappropriate way (it still hasn't put its recommendation system back online.) Similarly, Amazon took some heat when it started cross-promoting its new clothing site by recommending clean underwear to people who were shopping for DVDs. (Porter, 2006)

Cold start problem - there are only a few ratings on which to base recommendations

(Adomavicius and Tuzhilin, 2005)
(Porter, 2006)
(Herlocker, et al., 2004)

Learning Rate - “Cold-start” situations (commonly referred to as the startup problem) refer to situations where there are only a few ratings on which to base recommendations. Learning rates are non-linear and asymptotic (quality can’t improve forever), and thus it is challenging to represent them compactly. (Herlocker, et al., 2004)

New user problem – user must rate enough items to yield accurate recommendations

(Adomavicius and Tuzhilin, 2005)

The user has to rate a sufficient number of items before a content-based recommender system can really understand the user’s preferences and present the user with reliable recommendations. Therefore, a new user, having very few ratings, would not be able to get accurate recommendations. (Adomavicius and Tuzhilin, 2005)

New item problem – new items need to be rated enough to be recommended

(Adomavicius and Tuzhilin, 2005)

New items are added regularly to recommender systems. Collaborative systems rely solely on users’ preferences to make recommendations. Therefore, until the new item is rated by a substantial number of users, the recommender system would not be able to recommend it. Adomavicius and Tuzhilin, 2005)

Overspecialization – narrow, obvious recommendations

(Adomavicius and Tuzhilin, 2005)

Overspecialization occurs when the system can only recommend items that score highly against a user’s profile, the user is limited to being recommended items that are similar to those already rated. (Adomavicius and Tuzhilin, 2005)

Intrusiveness

(Adomavicius and Tuzhilin, 2005)

Many recommender systems are intrusive in the sense that they require explicit feedback from the user and often at a significant level of user involvement. For example, before recommending any newsgroup articles, the system needs to acquire the ratings of previously read articles and, often, many of them. Since it is impractical to elicit many ratings of these articles from the user, some recommender systems use nonintrusive rating determination methods where certain proxies are used to estimate real ratings. For example, the amount of time a user spends reading a newsgroup article can serve as a proxy of the article's rating given by this user. However, nonintrusive ratings (such as time spent reading an article) are often inaccurate and cannot fully replace explicit ratings provided by the user. Therefore, the problem of minimizing intrusiveness while maintaining certain levels of accuracy of recommendations needs to be addressed by the recommender systems researchers. (Adomavicius and Tuzhilin, 2005)

Lack of incentive

(Adomavicius and Tuzhilin, 2005)
(Cosley, et al., 2003)
(Schafer, Konstan, and Reidl, 2001)

While ratings are the essential ingredient of any RS, obtaining them is often difficult, for a number of reasons:
• explicitly rating items or adding items to a database can be a cumbersome process,
• some users quickly need a recommendation as a one-off, and do not see any reason for interacting with such a system over a long period of time,
• having an RS merely for information retrieval when needed is not going to motivate users to either contribute to, or use the system, in the long run. (Adomavicius and Tuzhilin, 2005)

Privacy Concerns – no transparency in recommendations methods

(Cosley, et al., 2003)
(Schafer, Konstan, and Reidl, 2001)

we discuss some of the critical ***social acceptance issues*** surrounding recommender applications in E-commerce including ***privacy and trust***. Technologists often assume that the "best" recommender application is one that is fully automatic and completely invisible. Our study does not bear this assumption out at all. Customer comments and ratings can help sites ***supplement their credibility and create a greater sense of community***. Reviewers are likely to visit the site each time they consume a product since they enjoy sharing their opinions and comment readers may come to depend on reviews to help guide their purchases. (Schafer, Konstan, and Reidl, 2001)

Recommendations may be manipulated

(Cosley, et al., 2003)

We study two aspects of recommender system interfaces that may ***affect users' opinions***: the rating scale and the display of predictions at the time users rate items. ***Users can be manipulated***, though, tending to rate toward the prediction the system shows, whether the prediction is accurate or not Further, manipulators who seek to make the system generate artificially high or low recommendations might benefit if their efforts influence users to change the opinions they contribute to the recommender. (Cosley, et al., 2003)

S-RS-IR

Transparency of criteria used to generate recommendation

(Herlocker, et al., 2004)
(Porter, 2006)

As for transparency, understanding the inference leading to a recommendation (and agreeing with it) not only increases trust in the recommendation, and the system providing it, but also makes it more likely that the user will follow the recommendation. Using a similar approach, Herlocker et al [3] conducted an extensive study examining what effect explanations for collaborative filtering results have on the user's perception of the system. In testing different explanation interfaces, they found that explanations are important to users, because their own reasoning often does not match the inference mechanism of the system. Users were less likely to trust recommendations when they did not understand why certain items were recommended to them. Herlocker et al [3] suggest that a rating histogram of the user's closest neighbors is the most effective way of explaining the results of collaborative filtering. (Porter, 2006)

Leverage ratings from similar (nearest-neighbor) users

(Adomavicius and Tuzhilin, 2005)

"Collaborative systems use other users' recommendations (ratings), they can deal with any kind of content and recommend any items, even the ones that are dissimilar to those seen in the past."

Collaborative filtering and content-based hybrid design

(Adomavicius and Tuzhilin, 2005)
(Melville, Mooney, and Nagarajan, 2002)

"Several recommendation systems use a hybrid approach by combining collaborative and content-based methods, which helps to avoid certain limitations of content-based and collaborative systems" (Adomavicius and Tuzhilin, 2005)

"We overcome these drawbacks of CF systems by exploiting content information of the items already rated. Our basic approach uses content-based predictions to convert a sparse user ratings matrix into a full ratings matrix; and then uses CF to provide recommendations." (Melville, Mooney, and Nagarajan, 2002)

Contextual/ephemeral personalization

(Schafer, Konstan, and Reidl, 2001)
(Adomavicius and Tuzhilin, 2005)

"Recommenders that use current customer inputs to customize the recommendation to the customer's current interests provide ephemeral personalization. This is a step above non-personalized recommenders because it provides recommendations that are responsive to the customer's navigation and selection. Particular implementations may be more or less personal, however. A recommender application with a high degree of ephemeral personalization would be one that uses an entire current browsing session or shopping cart to recommend items. Conversely, a recommender application that simply attaches recommendations to the current item is nearly non-personalized. Ephemeral personalization is usually based on item-to-item correlation, attribute-based recommendation, or both. (Schafer, Konstan, and Reidl, 2001)

"The improvement over the traditional information retrieval approaches comes from the use of user profiles that contain information about users' tastes, preferences, and needs. The profiling information can be elicited from users explicitly, e.g., through questionnaires, or implicitly—learned from their transactional behavior over time." (Adomavicius and Tuzhilin, 2005)

Reduced organizational maintenance

(Porter, 2006)

Building recommendation systems is quite different from how we've built information-rich web sites in the past. For many designers the primary task of building an information-rich web site is creating navigation systems built on top of an underlying taxonomy. The taxonomy is built out of the designer's knowledge of users and the domain, generated from observations made during field research, insights from persona creation, or knowledge gained from other design techniques. Most of the organizational maintenance of a site is keeping the navigation system and taxonomy in line with the users' changing needs. (Porter, 2006)

W-RS-IR

Obviousness

(Adomavicius and Tuzhilin, 2005)

Obvious recommendations have two disadvantages: first, customers who are interested in those products have already purchased them; and second, managers in stores do not need recommender systems to tell them which products are popular overall. They have already invested in organizing their store so those items are easily accessible to customers. (Adomavicius and Tuzhilin, 2005)

Limited Accuracy/Incorrect Recommendations

(Economist, 2005)
(Schafer, Konstan, and Reidl, 2001)

A recent study by Jonathan Herlocker of Oregon State University and his colleagues evaluated several film-recommendation systems based on collaborative filtering. Using a five-point scale, it compared the scores users would be expected to give particular films, based on their known preferences, with the scores they actually gave. The predicted and actual scores differed by at least 0.73 points. Dr Herlocker speculates that this might be evidence for a fundamental limit to the accuracy of recommendation systems based on collaborative filtering. There is no point in making suggestions any more finely tuned than the variations in an individual's own opinions. (Economist, 2005)

An accurate system that only recommends consensus best-sellers provides less value than a system that can find and recommend more obscure books of interest to particular users. (Schafer, Konstan, and Reidl, 2001)

New user problem/cold start

(Adomavicius and Tuzhilin, 2005)
(Porter, 2006)
(Herlocker, et al., 2004)

New User Problem
The user has to rate a sufficient number of items before a content-based recommender system can really understand the user's preferences and present the user with reliable recommendations. Therefore, a new user, having very few ratings, would not be able to get accurate recommendations. (Adomavicius and Tuzhilin, 2005)

Learning Rate - "Cold-start" situations (commonly referred to as the startup problem) refer to situations where there are only a few ratings on which to base recommendations. Learning rates are non-linear and asymptotic (quality can't improve forever), and thus it is challenging to represent them compactly. (Herlocker, et al., 2004)

New item problem

(Adomavicius and Tuzhilin, 2005)

New items are added regularly to recommender systems. Collaborative systems rely solely on users' preferences to make recommendations. Therefore, until the new item is rated by a substantial number of users, the recommender system would not be able to recommend it.

Sparsity/scarcity of participants/ratings

(Adomavicius and Tuzhilin, 2005)

In any recommender system, the number of ratings already obtained is usually very small compared to the number of ratings that need to be predicted. Effective prediction of ratings from a small number of examples is important. Also, the success of the collaborative recommender system depends on the availability of a critical mass of users.

Inflexible design – based on algorithm logic

(Adomavicius and Tuzhilin, 2005)
(Bates, 1998)

Content-based techniques are limited by the features that are explicitly associated with the objects that these systems recommend. Therefore, in order to have a sufficient set of features, the content must either be in a form that can be parsed automatically by a computer (e.g., text) or the features should be assigned to items manually. (Adomavicius and Tuzhilin, 2005)

Most of the recommendation methods are inflexible in the sense that they are "hard-wired" into the systems by the vendors and, therefore, support only a predefined and fixed set of recommendations. Therefore, the end-user cannot customize recommendations according to his or her needs in real time. (Adomavicius and Tuzhilin, 2005

Rouse & Rouse [49] note, after an extensive survey of the literature of information seeking behavior: Because information needs change in time and depend on the particular information seeker, systems should be sufficiently flexible to allow the user to adapt the information seeking process to his own current needs. Examples of such flexibility include the design of interactive dialogues and aiding techniques that do not reflect rigid assumptions about the user's goals and style (p. 135). (Bates, 1998)

S-RS-ID

Serendipitous Browsing and Discovery

(Economist, 2005)
(Herlocker, et al., 2004)
(Schafer, Konstan, and Reidl, 2001)
(Porter, 2006)
(Herlocker, et al., 2004)
(Melville, Mooney, and Nagarajan, 2002)

Novelty & Serendipity increase user confidence in the system. A serendipitous recommendation helps the user find a surprisingly interesting item he might not have otherwise discovered. (Herlocker, et al., 2004)

“Great for Discovery - Recommendation systems help alleviate this problem because they allow us to discover things that are similar to what we already like…they can make some pretty surprising recommendations that we probably wouldn't have found out about otherwise…. while people overall preferred recommendations from their friends, they appreciated the ability of an RS to provide serendipitous recommendations that broadened their horizons.” (Porter, 2006)

Content-based methods can uniquely characterize each user, but CF still has some key advantages over them. Firstly, CF can perform in domains where there is not much content associated with items, or where the content is difficult for a computer to analyze — ideas, opinions etc. Secondly a CF system has the ability to provide serendipitous recommendations, i.e. it can recommend items that are relevant to the user, but do not contain content from the user’s profile. (Melville, Mooney, and Nagarajan, 2002)

Passive/Organic Recommendations

(Schafer, Konstan, and Reidl, 2001)

“Sometimes referred to as “organic” recommendations, passive delivery presents the recommendation in the natural context of the rest of the E-commerce application. (Schafer, Konstan, and Reidl, 2001)

Social/Profile Connections – matching users Builds Community

(Schafer, Konstan, and Reidl, 2001)
(Economist, 2005)

“Where the user of a search engine is on a solitary quest, the user of a collaborative-filtering system is part of a crowd. Search, and you search alone; ramble from one recommendation to another, and you may feel a curious kinship with the like-minded individuals whose opinions influence your own—and who are, in turn, influenced by your opinions "A search-engine user hunts alone; the user of a collaborative-filtering system is part of a crowd." (Economist, 2005)

Cross- Selling Opportunities

(Economist, 2005)
(Schafer, Konstan, and Reidl, 2001)

“But the value of collaborative filtering has, in any case, already been established. It helps people find things they might otherwise miss, and helps online retailers increase sales through cross-selling.” (Economist, 2005)

“Recommendations have the advantage of reaching the customer at the time when the customer is already receptive to the idea. Indeed, E-commerce uses passive recommendation as part of the ordering process, suggesting upgraded shipping options, for example, at the time when the customer is completing a purchase (where it is much more effective than asking about shipping on a link off the home page).” (Schafer, Konstan, and Reidl, 2001)

Builds user Trust and Loyalty

(Schafer, Konstan, and Reidl, 2001)
(Bielenberg and Zacher, 2005)
(Herlocker, et al., 2004)
(Swearingen and Sinha, 2001)
(Bonhard and Sasse, 2006)
(Marlow, et al., 2006)

Finally, user control and transparency of recommendations were introduced as means to foster trust in recommender systems. Control and transparency are provided by feedback mechanisms and interfaces with high social awareness of the environment a recommendation was made in. In other words: the better social awareness in a recommender systems is, the better the quality of recommendations in terms of trust of the recipient. Social awareness in return is dependent on the quality of the facts it is based on which are determined by the collaborative filtering algorithm. Thus, social awareness and recommender functionality turn out to be mutually influencing. (Bielenberg and Zacher, 2005)

Trust - users must develop trust in a recommender system, and recommendations of familiar items supports this process. Explanations of why an item was recommended also helped users gain confidence in a system’s recommendations.(p.47) the availability and quality of “supporting information” a system provided—for example, synopses, reviews, videos or sound samples—was a significant factor in predicting how useful users rated the system. (Herlocker, et al., 2004)

Design Suggestion: Our design suggestion is that systems should take measures to enhance user’s trust. However, it would be difficult for any system to insure that some percentage of recommendations were previously experienced. A possible way to facilitate this would be to generate some very popular recommendations, classics that the user is likely to have watched / read before. Such items might be flagged by a special label of some kind (e.g., “Best Bets”). (Swearingen and Sinha, 2001)

As for transparency, understanding the inference leading to a recommendation (and agreeing with it) not only increases trust in the recommendation, and the system providing it, but also makes it more likely that the user will follow the recommendation. (Bonhard and Sasse, 2006)

Supports natural “Berrypicking” information retrieval

(Bates, 1998)

A model of searching called "berrypicking' has been proposed here, which, in contrast to the classic model of information retrieval, says that
•typical search queries are not static, but rather evolve
•searchers commonly gather information in bits and pieces instead of in one grand best retrieved set
•searchers use a wide variety of search techniques which extend beyond those commonly associated with bibliographic databases
•searchers use a wide variety of sources other than bibliographic databases. Bates, 1998)

W -RS-ID

Lack of or too broad of context in recommendations

(Adomavicius and Tuzhilin, 2005)
(Dye, 2006)
(Bielenberg and Zacher, 2005)

Sometimes recommendations are wrong. In extreme cases recommendations can be offensive. For example, Wal-Mart got into serious hot water last year when its movie recommendation system recommended movies in an inappropriate way (it still hasn't put its recommendation system back online.) Similarly, Amazon took some heat when it started cross-promoting its new clothing site by recommending clean underwear to people who were shopping for DVDs. (Adomavicius and Tuzhilin, 2005)

The drawbacks of folksonomies are usually just the flip sides of their advantages. For instance, a rich variety of tags can give users a broad context for the search, but it can also limit the findability of a specific piece of information, which could be found under any of its tags. Tags are based on personal associations, but if the community's popular associations don't match up with your—or their choices in spelling and punctuation aren't what you expect—then you might have difficulty finding what you need. (Dye, 2006)

To estimate the value of metadata the context of its creation always has to be considered. Otherwise metadata may be ambiguous, it may contradict other statements, it even may be wrong. The question is how individual metadata can be valuable for a broader audience while minimizing these problems. (Bielenberg and Zacher, 2005)

The current generation of recommender systems operates in the two-dimensional User Item space. That is, they make their recommendations based only on the user and item information and do not take into consideration additional contextual information that may be crucial in some applications. the recommender system must take additional contextual information, such as time, place, and the company of a user, into consideration when recommending a product. it is important to extend traditional two-dimensional User Item recommendation methods to multidimensional settings. In addition, [43] argued that the inclusion of the knowledge about the user's task into the recommendation algorithm in certain applications can lead to better recommendations. (Adomavicius and Tuzhilin, 2005)

Intrusiveness of recommendation results

(Adomavicius and Tuzhilin, 2005)

Many recommender systems are intrusive in the sense that they require explicit feedback from the user and often at a significant level of user involvement. For example, before recommending any newsgroup articles, the system needs to acquire the ratings of previously read articles and, often, many of them. Since it is impractical to elicit many ratings of these articles from the user, some recommender systems use nonintrusive rating determination methods where certain proxies are used to estimate real ratings. For example, the amount of time a user spends reading a newsgroup article can serve as a proxy of the article's rating given by this user. However, nonintrusive ratings (such as time spent reading an article) are often inaccurate and cannot fully replace explicit ratings provided by the user. Therefore, the problem of minimizing intrusiveness while maintaining certain levels of accuracy of recommendations needs to be addressed by the recommender systems researchers.

Poor Design and Placement of Recommendation Outputs (usability)

(Adomavicius and Tuzhilin, 2005)
(Schafer, Konstan, and Reidl, 2001)

Output recommendations of specific items vary in type, quantity, and look of the information provided to the customer. The most common type of output can be considered a suggestion. More commonly, recommender systems provide a set of suggestions for a customer in a particular context. Some application designers prefer to leave the list unordered, to avoid giving the impression that a particular recommendation is the best one. Unordered lists may avoid premature customer dismissal of an entire set of recommendations based on rejection of the first one. (Schafer, Konstan, and Reidl, 2001)

Passive Design of recommendation placement - Matching the delivery of recommendations to the customer's activity is a critical design decision in E-commerce recommender systems, just as it is in traditional marketing. Sometimes referred to as "organic" recommendations, passive delivery presents the recommendation in the natural context of the rest of the E-commerce application. Examples of passive recommendation include displaying recommendations for products related to the current product (Amazon.com's Customers Who Bought feature), displaying recommendations for products related to the topic of a text article(CDNOW's Artist Picks) and displaying recommendations in the context of exploration (Drugstore.com's Advisors). Passive recommendation has the advantage of reaching the customer at the time when the customer is already receptive to the idea. Indeed, E-commerce uses passive recommendation as part of the ordering process, suggesting upgraded shipping options, for example, at the time when the customer is completing a purchase (where it is much more effective than asking about shipping on a link off the home page). A possible disadvantage of passive recommendations is that customers may not actively notice them, but we are not aware of any research that suggests that noticing recommendations explicitly makes them more effective than having them as part of the overall experience. Therefore when users receive recommendations from an RS without any meaningful explanation, the recommendation lacks the cues associated with one from a real person and appears more like a search result. This is a problem an RS should solve rather than create. (Adomavicius and Tuzhilin, 2005)

Loss of user trust and loyalty if recommender techniques not disclosed

(Schafer, Konstan, and Reidl, 2001)
(Herlocker, et al., 2004)

Trust – users must develop trust in a recommender system, and recommendations of familiar items supports this process. ***Explanations of why an item was recommended also helped users gain confidence in a system's recommendations***.(p.47) the availability and quality of "supporting information" a system provided—for example, synopses, reviews, videos or sound samples—was a significant factor in predicting how useful users rated the system. (Herlocker, et al., 2004)

Inflexible – lack of user manipulation of recommendations

(Adomavicius and Tuzhilin, 2005)

Most of the recommendation methods are inflexible in the sense that they are “hard-wired” into the systems by the vendors and, therefore, ***support only a predefined and fixed set of recommendations. Therefore, the end-user cannot customize recommendations*** according to his or her needs in real time. (Adomavicius and Tuzhilin, 2005)

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