A Comparative Study of Features of Graph Database-Driven Knowledge Management Applications: A Case Study of Roam Research (Postprint)

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Abstract

[Purpose / Significance] This study analyzes the characteristics of graph database-driven novel knowledge management tools to enable researchers and users in the knowledge management community to improve and enhance their knowledge communication methods and knowledge output efficiency. [Method / Process] It reviews the problems encountered by traditional knowledge management tools, takes Roam Research as an example, and demonstrates the beneficial characteristics of graph database-driven knowledge management applications through comparative analysis. By reviewing literature and comparing other forms of knowledge collaboration, it prospects the new opportunities this novel application brings to knowledge communities. [Result / Conclusion] Through comparative analysis and case studies, it is concluded that Roam Research's characteristics such as fine granularity, bidirectional linking, visual graph, open API, and Ad hoc structure can significantly expand the capability scope of knowledge management tools, and provide a foundation for collaboration in large-scale nonlinear knowledge communities and rapid knowledge production. The transformation of thinking patterns amid technological development and information overload environments deserves sufficient attention and tracking from researchers in the fields of knowledge management, knowledge communities, and knowledge production.

Full Text

Preamble

Comparative Research on the Characteristics of Graph Database-Driven Knowledge Management Applications: Taking Roam Research as an Example

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Abstract:
[Purpose/significance] This paper analyzes the characteristics of a new knowledge management tool driven by graph databases for researchers and users in the knowledge management community. This will improve and enhance the exchange of knowledge and improve the efficiency of knowledge production. [Method/process] This paper compared the problems encountered in traditional knowledge management tools and showed beneficial features of knowledge management applications driven by graph database in a comparative manner by taking Roam Research as an example. By combing the literature, we compared other forms of knowledge collaboration and looked forward to the new opportunities that this new application brought to knowledge communities. [Result/conclusion] Through comparative analysis and case research, this paper concludes that features of Roam Research such as fine grit, bidirectional link, visual graphs, open interfaces and Ad hoc structures will significantly enhance the range of capabilities of knowledge management tools, and moreover, provide a basis for collaboration in large-scale nonlinear knowledge communities and rapid production of knowledge. The development of technology and the transformation of the way of thinking in the information overload environment deserve enough attention and tracking by researchers in the fields of knowledge management, knowledge communities and knowledge production.

Keywords: Roam Research, knowledge communities, knowledge management

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1 Introduction

In the Internet era, the subjects of knowledge production have changed, and "User-Generated Content" (UGC) has gradually become mainstream. People are considering how to effectively record and reorganize acquired information and knowledge to potentially generate value-added and innovation. Note-taking is the primary method of knowledge management, and the development of information technology has made digital note-taking an increasingly important means of recording and learning. Consequently, people have begun to attach greater importance to the concepts and methods of knowledge management, applying them in digital note-taking applications.

The massive emergence of knowledge has made issues such as the effectiveness of knowledge storage and the complexity of management increasingly prominent. Functional limitations of some knowledge management platforms have triggered problems and challenges in the knowledge management field regarding concepts, management, and technology. Faced with large amounts of information generated through storage, access, and distribution, one major challenge is how to digest it. The advent of digital note-taking provides a possible solution to this problem. In traditional note-taking tools, text information content mostly adopts a tree-like organizational form. However, this tree structure creates difficulties for information classification, as the same note may belong to both category 1 and category 2. To address the problems of tree structures, some note-taking tools recommend using tags to assist or replace classification methods. Meanwhile, keywords also suffer from polysemy issues. Overly simplistic tag-based processing may lead to an inability to find the source of notes during retrieval, turning the knowledge base into a "graveyard of knowledge." These problems also exist in team and public knowledge base construction with multiple participants, and are even more complex in such contexts.

Roam Research was officially launched in June 2020. This knowledge management tool is driven by graph databases and features fine granularity, bidirectional linking, visual graphs, open interfaces, and Ad hoc structures. This paper attempts to conduct a comparative analysis of these characteristics, explain their advantages over traditional note-taking tools, and explore the prospects of Roam Research for knowledge community collaboration.

2 Related Research

Communication between people helps stimulate knowledge output. Research has shown that when attention cannot be concentrated, it triggers profound reflection among scientists, making them realize the importance of knowledge linking. Knowledge linking is not only an open and collaborative process but can also bring various collaborative possibilities to knowledge flow through the distributed characteristics of networks, with lower organization and sharing costs. As knowledge flows between different groups, it can reorganize old knowledge and generate more innovative knowledge combinations.

In the early days of the World Wide Web, marked by hyperlinks, scholars envisioned similar scenarios. Tim Berners-Lee, the "father of the World Wide Web," initially conceived a project based on a hypertext system to facilitate sharing and updating information among researchers. Although the Web's role and impact in communication have become increasingly evident, its form has gradually evolved into a large-scale directed graph, and these links are unidirectional. The unidirectionality of links and the coarse granularity of nodes have prevented this vision from becoming a reality.

After the emergence of Niklas Luhmann's Zettelkasten Method, this vision was gradually realized. Lüdecke mentioned in his book that this method can connect notes to form a networked hypertext note system, enabling people to review and traverse without getting lost. Meanwhile, the database technology behind note-taking tools has also been quietly changing. From tree-like file organization to SQL databases, and even to unstructured databases represented by XML and JSON, all represent different developers' continuous response to and iteration on user needs. The development of graph databases has enabled note-taking tools to perform more flexible and complex operations using associations between data, beyond just recording and retrieval.

Vannevar Bush believed that linking things together is necessary because human thinking operates through association. To this end, he proposed the Memex conceptual model, which would allow people to quickly find needed information when necessary. Roam Research absorbed the original concepts of Bush and Ted Nelson, constructing a nearly complete hypertext concept and implementing several key features: addressability at the text block level, transclusion, and bidirectional linking. This nonlinear knowledge organization form, represented by Roam Research, better meets current needs for diverse and distributed fragmented knowledge and emphasizes knowledge collaboration through "bidirectional linking."

3 Feature Analysis

[Figure 1: see original paper] from L. Cabrelli's "Roam for Results" shows Lisa City, which can be viewed as a small Roam Research database containing three pages. Each rectangular block (Road, Ave, or Street) represents a page, while the solid or dashed squares represent blocks (paragraphs), and the links between them represent page reference relationships. To demonstrate the beneficial characteristics of graph database-driven knowledge management applications, the authors conducted an in-depth comparison of several note-taking tools across six dimensions, with results shown in .

The comparison reveals Roam Research's advantages. First, in Roam Research, the minimum granularity of recording can be a paragraph or even a block, breaking through the traditional minimum recording granularity of "one note." Second, Roam Research's bidirectional linking capability allows examining all nodes that link to a particular node at that node itself. Finally, Roam Research supports presenting global or partial network graphs and possesses precise query syntax functionality. Although Evernote has similar visualization and query functions, it and the other note-taking tools adopt tree-like organizational forms. As records increase, this traditional linear organization becomes 不利于知识的浏览与回顾.

Human thinking is not linear. Roam Research's networked organizational structure helps users organize ideas and make them associate and collide with each other, aligning more closely with how the human brain operates. Simultaneously, Roam Research can share the most original records with others, allowing other users to intuitively see how this knowledge is organized. Therefore, Roam Research provides new foundational conditions for entirely new knowledge collaboration, and even knowledge production, teaching, and dissemination.

3.1 Bidirectional Linking

Traditional note-taking tools adopt a tree-like organizational form as shown in [Figure 2: see original paper], where each leaf (each note) belongs to a clear, single branch node (subdirectory). While notes are standardized and neat, the entire storage process requires decision-making. Placing content in the same folder or subdirectory reduces the possibility of association between notes, loses their context, and ultimately forms a "graveyard of knowledge." The dashed line between notes B and C in [Figure 2: see original paper] represents that although these two notes can be associated, the link is unidirectional—node C cannot display node B that linked to it.

Roam Research's bidirectional linking capability lies in its ability to show all nodes that link to a particular node at that node itself. As shown in the dashed box in [Figure 3: see original paper], nodes B and C belong to the same page or are connected through the same tag. In this case, node C can easily find node B without linking, and vice versa. When node B links to a new node A, node A can be found by following the links, and node B can also be displayed at node A. Through this association, starting from any of the three nodes, the other two nodes can be found. With the same three nodes, Roam Research's bidirectional linking network organization has stronger retrieval capabilities, more clues, and more flexible organizational forms. Moreover, when users search and match, unlinked blocks are presented, making it more convenient to help users discover potential connections and evolve weak connections between knowledge into strong connections. Roam Research's bidirectional linking function not only reduces the cost of building knowledge networks but also enhances users' willingness to record.

3.2 Fine Granularity

"Granularity" refers to the smallest unit of the note network. When recording, users need to ensure "atomicity" of notes—each note should not contain too much text and should ideally describe only one central concept. Most users hold this belief because the minimum granularity of previous note applications was "one note." Only through this kind of minimization can difficulties in finding and retrieving be avoided when establishing associations between notes later.

In Roam Research, the minimum granularity is not "one note" but "one block." Roam Research uses an outline-style page structure where one block corresponds to one paragraph. Generally, paragraphs themselves have atomic characteristics and do not require users to disassemble them manually. As shown in [Figure 4: see original paper], assuming note node A is associated with note node B, node B can be found by following the index from node A—a common feature of general note-taking tools. Roam Research's bidirectional linking capability, however, allows seeing all nodes that link to it at node B.

Each note (page) includes several adjacent blocks (the dashed box represents that block 1 and block 2 in note A are two adjacent blocks). Note B can choose to link directly to note A, link to a block within note A, or link a block from note B to a block in note A. The double-arrowed lines between adjacent blocks represent that different blocks within each note can be bidirectionally linked.

Roam Research reduces the granularity of note recording. Users can link to any block under an outline note when recording and can quickly locate it to obtain precise and complete context, allowing them to focus only on thinking and output. Moreover, when users need to review notes and establish knowledge links, smaller granularity can provide more association dimensions and even catalyze thinking. Since any two adjacent blocks can naturally form contextual associations on the page, every block and paragraph becomes a unit that can be referenced, linked, and indented, so users do not need to consider the amount of text when recording, nor do they need to link every block.

3.3 Visual Graphs

Knowledge graphs have been widely applied in knowledge engineering, natural language processing, data management, and machine learning. Graph database-driven citation indexes like SCI have also been well utilized in journal literature management, where the graph database network makes citation relationships between documents clearer and reveals their internal connections. Human memory networks and organizational knowledge networks can also be represented as concept maps. Joseph D. Novak developed concept mapping techniques at Cornell University in the 1970s and applied them as a teaching technology to optimize understanding in science education. In Novak's book *Learning How to Learn*, he stated: "Meaningful learning involves the assimilation of new concepts and propositions into existing cognitive frameworks."

Roam Research supports automatic presentation of partial or complete knowledge graphs, allowing existing concept networks to be displayed in graph form without manual drawing. By browsing graphs and employing standardized technique training, users can discover connections across hierarchical levels. In most cases, these connections are more important than hierarchical ones because they can break through cognitive boundaries—the source of emergent creativity. Additionally, Roam Research supports exporting visual graphs, enabling further utilization of professional graph analysis tools for breakthrough discoveries. As shown in [Figure 5: see original paper], visually presented graphs can help users examine naturally emerging knowledge structures from a systemic perspective.

3.5 Ad Hoc Structure

Roam Research's structure is not fixed and can form dynamic organizational results of special networks (Ad hoc) according to users' current task requirements. Every note and every block prompts the number of citations. Clicking on a note's "citation number" lists all associated content, which is further associated with page context, date and time, and related tags. This allows users to form different style views for the same stored content according to their needs. Roam Research also supports standard query expressions, allowing users to define queries based on logical combinations of page titles. [Figure 8: see original paper] shows a query and its results for finding work tasks in the author's note library.

Currently, Roam Research only has an online version, but the "web version first" approach brings higher openness. Users can rely on front-end programming capabilities to deeply customize Roam Research and disseminate their extensions through the community, accelerating the popularization of excellent features. For example, users can adjust the theme interface by setting CSS styles to make tag colors and other styles better fit recording habits. Chrome extensions like Roam Toolkit also help users more conveniently retrieve note library content and use richer shortcut keys. RoamHack's 42SmartBlocks, as shown in [Figure 6: see original paper], advances Roam Research's functional extension by providing users with the ability to customize dynamic templates that can generate commonly used templates with one click. It can also quickly convert any content in Roam Research into an "intelligent workflow," allowing users to embed certain commands (code snippets) or even JavaScript into the workflow to perform dynamic operations, as shown in [Figure 7: see original paper]. Similar extension functions like 42SmartBlocks not only empower Roam Research users' personalized knowledge management needs but also realize the knowledge management community's long-standing expectation of "algorithms for thought."

In Roam Research, task management is integrated with pages, tags, time, and other elements, allowing users to find tasks that simultaneously meet date ranges, task types, and status, thereby organically combining knowledge management with task management and enabling users to address task scheduling and content production needs in one place.

4 Knowledge Communities Based on Roam Research

Using note-taking tools for collaboration is not new—EverNote, WizNote, Notion, and others all support sharing pages with team members for co-editing. Roam Research's collaboration can also directly present nonlinear thinking organizational forms to collaborators without adopting a tree-like grammatical structure.

[Figure 9: see original paper] shows the author's note network graph containing the keyword "Python" recorded over a period of time. Notes naturally form several clusters, displaying citation relationships within them. When sharing this network information, the knowledge creator's thinking focus, thematic direction, and context can be clearly displayed to collaborators, making collaboration more precise. This enables user communication to become more frequent, direct, and efficient. Therefore, Roam Research can provide the foundational conditions for the popularization of nonlinear knowledge communities.

To locate the position of nonlinear knowledge communities, the authors 梳理了维基百科、学术系统、问答社区以及去中心化代码仓库的特点，并与 Roam Research 构成的非线性知识社区进行对比，结果如表 2 所示. As seen in , the underlying infrastructure changes provided by Roam Research can empower individuals or groups in knowledge communities, bringing benefits to knowledge exchange, publishing, education, research, and social enterprises, and even changing the ecological evolution of these fields in the future. In the education field, such nonlinear knowledge communities already have examples. For instance, L. Cabrelli created a course on Roam Research academic writing on Teachable, using a public Roam Graph database to share course content, related configurations, and dynamic 42SmartBlocks templates, allowing users to participate in real-time content generation and interactive Q&A. Although nonlinear knowledge communities share similarities with Wikipedia, academic systems, Q&A communities, and decentralized code repositories like GitHub, research on them is still in its early stages.

5 Conclusion

The emergence of nonlinear thinking connection tools like Roam Research provides strong support for achieving orderly and efficient knowledge organization. Through in-depth comparative analysis of several representative note-taking tools including EverNote, OneNote, MarginNote, and Youdao Cloud Notes, this study found that Roam Research's features—bidirectional linking, visual graphs, query syntax, and fine granularity—effectively solve current problems in knowledge management regarding storage effectiveness and management complexity. In addition to Roam Research, other dual-link note-taking tools such as Huluxia BiJi, RoamEdit, and Obsidian are also developing rapidly. Meanwhile, some traditional note-taking tools are adding bidirectional linking functions, such as Evernote and Notion.

While dual-link note-taking tools are developing rapidly, their theories and characteristics still require research. In an open innovation environment, although knowledge management applications like Roam Research are conducive to promoting diversified knowledge display and value-added innovation, they also have certain limitations, such as the need to improve mobile user experience. Meanwhile, academic research on nonlinear knowledge communities is still in its early stages, and some mechanism characteristics require further study.

Knowledge exchange in nonlinear knowledge communities is more direct and efficient than traditional knowledge exchange and communication media, which will profoundly change academic research and education forms in the future. In future work, the authors will continue to explore, discover, and track changes and developments in related characteristics through the use of this tool.

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Author Contributions

Wang Shuyi: Proposed the topic, formulated the framework, and revised the manuscript.
Zhang Jin: Collected materials and drafted the manuscript.
Li Jun: Revised the manuscript.

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