Postprint: Research on Interoperability Elements and Mechanisms of Multimedia Network Public Opinion Knowledge Base Groups

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Date: 2023-07-26T00:00:00+00:00

Abstract

[Purpose/Significance] The interoperability mechanism of multimedia network public opinion knowledge base clusters can provide fast, efficient, and accurate network public opinion monitoring services for government regulatory departments. [Method/Process] Based on an exploration of relevant research on the interoperability of multimedia network public opinion knowledge base clusters, this study analyzes the elements and mechanisms of such interoperability, elaborates on the interoperability mechanism from seven aspects: data aggregation, sub-database collaboration, scheduling control, algorithm matching, demand feedback, interactive service, and protocol adaptation, and deeply analyzes the interactive relationships among mechanisms, elements, and processes, as well as among the mechanisms themselves. [Results/Conclusion] This research enhances the fundamental theoretical studies on the interoperability of multimedia network public opinion knowledge base clusters, providing a reliable theoretical foundation for their construction.

Full Text

Research on Interoperability Elements and Mechanisms of Multimedia Network Public Opinion Knowledge Base Groups

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Abstract

[Purpose/Significance] The interoperability mechanism of multimedia network public opinion knowledge base groups can provide rapid, efficient, and

precise network public opinion monitoring services for government regulatory departments. [**Method/Process**] Building upon existing research on multimedia network public opinion knowledge base group interoperability, this paper analyzes the interoperability elements and mechanisms from seven perspectives: data aggregation, sub-database collaboration, scheduling control, algorithm matching, demand feedback, interactive service, and protocol adaptation, while also examining the interactions among these mechanisms and their relationships with operational elements and processes. [**Result/Conclusion**] This study advances the foundational theoretical research on multimedia network public opinion knowledge base group interoperability, offering a reliable theoretical basis for constructing such systems.

Keywords: multimedia; network public opinion; knowledge base groups; interoperability
Classification Number: G251
DOI: 10.13266/j.issn.0252-3116.2019.20.005

1. Introduction

How to achieve interoperability among heterogeneous knowledge bases to provide cross-platform and cross-system knowledge association, discovery, and mining for information management departments and government agencies represents a critical challenge that academia is actively addressing [1]. The interoperability of network public opinion knowledge base groups containing diverse types of opinion information serves as an effective method for enabling cross-browsing and integrated retrieval of big-data multimedia public opinion information, and constitutes a necessary means for acquiring, storing, and utilizing such data.

Traditional knowledge base interoperability suffers from numerous problems that can be broadly categorized into two dimensions: organizational deficiency and technical heterogeneity [2]. Organizational deficiency leads to a lack of long-term planning and coordination capacity among subsystems, inevitably resulting in compatibility and interoperability issues as systems develop independently. Technical heterogeneity emerges as an inevitable consequence of system evolution, as different systems employ diverse technologies to achieve various functions, and these technologies often exhibit mutual exclusivity. Technical heterogeneity manifests in several ways: (1) heterogeneity in knowledge base hardware platforms; (2) fundamental system heterogeneity caused by differences in operating systems, file systems, and communication mechanisms; (3) database management system heterogeneity due to data model variations; (4) application program heterogeneity resulting from programming languages and algorithms; and (5) data format and structural heterogeneity.

Within the field of knowledge base interoperability research, scholars have analyzed application environments from knowledge management, knowledge services, and research education perspectives, constructing responsive interoper-

ability frameworks that consider technical, semantic, and managerial interoperability alongside stakeholder requirements [3]. Some researchers have proposed interoperability frameworks and interface models focusing on knowledge base interoperability interfaces [4-5]. Others have conducted in-depth studies on interoperability standard protocols, constructing multi-layer technical architecture models to achieve data integration among heterogeneous underlying data sources [6]. Using grounded theory, researchers have summarized influencing factors in knowledge base interoperability and examined their organic interconnections to reveal the underlying mechanisms [7]. Additionally, studies have analyzed interoperability willingness, motivations, and functional differences between research information systems and knowledge bases, exploring applications in research data management [8].

While these studies have addressed institutional knowledge base interoperability issues, traditional approaches struggle to cope with the acquisition, processing, utilization, and tracking of multimedia network public opinion in big data environments. The constantly evolving elements of multimedia network public opinion information in such environments exacerbate the complexity and volatility of online opinion dynamics. Furthermore, since institutional knowledge bases were not originally designed with subsequent interoperability in mind, this increases the difficulty of achieving interoperability among multimedia network public opinion knowledge base groups. This paper examines multimedia network public opinion knowledge base group interoperability from a novel perspective, analyzing its mechanisms based on operational elements and exploring the interactions among elements, processes, and mechanisms to provide theoretical support for establishing and improving multimedia network public opinion knowledge base group systems.

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2. Characteristics of Multimedia Network Public Opinion Knowledge Base Group Interoperability

2.1 Data Heterogeneity Multimedia network public opinion information comprises four interrelated elements: network opinion subjects, objects, ontologies, and media, which together constitute complete multimedia network public opinion information [10]. Consequently, the information data structure stored in multimedia network public opinion knowledge base groups differs from traditional data architectures. The relational databases constructed must align with the inherent characteristics of multimedia network public opinion information to establish logical frameworks and relationships.

The subject data, object data, ontology data, and media data of multimedia network public opinion information are stored in heterogeneous databases. This information encompasses all attributes including text, audio, video, images, and URLs, with each attribute type forming a single entity set that creates a logical whole through associative relationships, ultimately manifesting in multimedia

network public opinion knowledge base groups. Data heterogeneity is reflected in multiple analysis perspectives, storage difficulties, and strong data correlations. The knowledge connotation of multimedia network public opinion information exists within each attribute type and their interconnections; analyzing multimedia network public opinion data from a single data perspective leads to partial results and loss of knowledge 内涵. Therefore, multimedia network public opinion knowledge base groups must serve as the storage environment, combined with interoperability mechanisms, for storing, mining, and analyzing this knowledge.

Based on the connotation of multimedia network public opinion and the characteristics of knowledge base groups, we define interoperability as the capacity of different sub-databases to utilize information or conduct knowledge discovery based on shared information. Multimedia network public opinion knowledge base groups represent a solution addressing knowledge storage, fusion, and analysis challenges posed by massive heterogeneous big data public opinion information. Such systems provide technical support for semantic identification, risk assessment, crisis response, and concurrent acquisition of multimedia network public opinion data, dynamically updating sub-database data through semi-supervised learning to cope with multimodal information outbreaks and complex environmental mutations. The integrity, extensibility, and knowledge-sharing capabilities of these base groups establish foundations and conditions for subsequent semantic identification and crisis response. Logically distributed, these systems exhibit wholeness, systematicity, and synergy, while physically distributed across different physical nodes.

2.2 Multi-System Nature Multimedia network public opinion knowledge base group interoperability emphasizes collaborative capabilities among individuals, institutions, and repositories with different information types to achieve data interaction, migration, and sharing. In big data environments, manual processes or simple applications cannot handle massive data exchanges between base groups, necessitating interoperating systems with concurrency, independence, and asynchrony to coordinate entire group operations. These systems require control mechanisms covering all aspects of sub-database interoperability, including data maintenance, access control, security management, and more. The interoperability process is formed through single or multiple connections between sub-databases, with their interoperating systems collectively constituting the multimedia network public opinion knowledge base group interoperating system.

The multi-system nature manifests in two aspects: First, in heterogeneous sub-databases with multi-state data structures. Due to data heterogeneity, association rules, mining algorithms, and analysis methods vary significantly. To address data complexity, base groups establish databases containing corresponding rule libraries to store multimodal network public opinion information. Second, in independent heterogeneous sub-database management systems. From

a database perspective, the coexistence and collaborative operation of multiple sub-database types rely on both the overall group management system and individual sub-database management systems. Sub-database management systems control network public opinion information within their databases, while the group management system coordinates concurrent processes to ensure efficient and orderly interoperability.

2.3 Independent Service Orientation Establishing multimedia network public opinion knowledge base groups aims to provide data support for network opinion crisis early warning, response, and concurrent acquisition monitoring operations for regulatory departments. This distinguishes multimedia network public opinion knowledge base group interoperability from traditional knowledge base interoperability in its service orientation. Traditional knowledge bases serve large user populations with shallow knowledge mining across broad domains, primarily serving participating users, community members, and general network users seeking conventional domain knowledge [11].

In contrast, multimedia network public opinion knowledge base groups serve decision-making users such as opinion analysts and government regulatory decision-makers. Through interoperability, these systems integrate multimodal opinion data, multi-structured sub-databases, and multi-perspective mining algorithms to conduct comprehensive and diversified deep analysis of network opinion information. They provide services including crisis event warnings, response protocols, and subsequent tracking for decision-makers, offering highly relevant knowledge tailored to multimedia network public opinion.

2.4 Diversified Information Sources Traditional knowledge base information sources include expert knowledge, books, documents, and archives, with limited channels and narrow applicability resulting in low scalability and mining potential. Multimedia network public opinion knowledge base groups incorporate diversified channels beyond conventional sources. This diversity enables structured, semi-structured, and unstructured data attributes, with dissemination media including PC terminals, mobile devices, and traditional media through network news, online videos, social networks, and other applications.

Traditional knowledge bases cannot adapt to the diversified acquisition channels and massive data volumes of current multimedia network public opinion information. Multimedia network public opinion knowledge base groups were developed to address these acquisition difficulties. Diverse information sources provide a data foundation for deep knowledge mining and multiple analytical approaches. Through multi-system operations, these groups acquire network opinion information from various channels, maximizing data utilization to reconstruct network opinion events and provide technical support for knowledge acquisition.

3. Elements of Multimedia Network Public Opinion Knowledge Base Group Interoperability

During interoperability processes, five elements—multimedia network public opinion data, knowledge interaction algorithms, sub-databases, interoperability standards, and scheduling control—collaborate synergistically to form the complete interoperability mechanism.

3.1 Multimedia Network Public Opinion Data Multimedia network public opinion data constitutes the most fundamental element and underlying support for interoperability. Data types include text, images, audio, video, and URLs, while data structures comprise subject data, object data, ontology data, and media data. This data forms the most critical component of base group construction, serving as the foundation for subsequent information aggregation, analysis, and utilization. The volume and quality of data acquisition fundamentally determine analysis outcomes for network opinion crisis events.

This data includes not only conventional data types and descriptive files but also attribute data such as user ID, age, gender, education level, repost counts, collection counts, like counts, and opinion leader metrics (follower counts, post counts, fan counts). From a monitoring perspective, both the data itself and its descriptive attributes can reveal implicit and explicit knowledge within multimedia network public opinion information, providing foundations for analyzing user information behavior, opinion heat indices, and dissemination patterns. Through mining algorithms, attribute data can reflect network opinion event connotations from multiple angles and levels, making descriptive attribute data an integral part of multimedia network public opinion information data.

3.2 Multimedia Network Public Opinion Knowledge Interaction Algorithms Multimedia network public opinion knowledge interaction algorithms refer to algorithmic sets describing production rules for network opinion knowledge generation, stored in algorithm repositories containing regulations and constraints for knowledge discovery. Association rules reflect interdependencies among opinion data, events, and knowledge, representing a crucial interoperability link that significantly impacts knowledge integrity, consistency, accuracy, flexibility, and system performance.

Algorithms are stored as independent database objects, with rules in algorithm repositories being independent of tables or user-defined data types in network opinion databases. Deleting or modifying databases does not affect connected rules. Therefore, database updates do not impact relevant rules in the rule repository. When knowledge mining generates rules, the repository compares them against stored rules, automatically updating the algorithm repository with new algorithms and associating them with other databases to achieve interoperability.

3.3 Multimedia Network Public Opinion Knowledge Base Group Sub-Databases Multimedia network public opinion knowledge base groups serve as the primary carriers and storage spaces for knowledge. The knowledge within provides technical support for semantic identification, risk assessment, crisis response, and concurrent acquisition. Regulatory departments obtain relevant data based on independent needs, while knowledge bases mine deep-level logic and complex rules to provide opinion knowledge and regulatory solutions.

As the final storage location for knowledge, knowledge base management systems: (1) manage stored knowledge, facts, and rules; (2) coordinate knowledge search and transfer between knowledge bases and inference engines to ensure precise queries; and (3) manage group control systems that organize sub-database interoperability, schedule functional modules, monitor interoperability processes, handle exceptions, and manage updates and maintenance.

Network opinion knowledge bases and databases maintain a feedback relationship: knowledge bases feed knowledge requirements to databases, which acquire relevant data accordingly, continuing the knowledge acquisition process and forming an interoperability cycle. Sub-database management systems control network opinion information within their databases, while group management systems coordinate concurrent processes to ensure efficient and orderly interoperability.

3.4 Multimedia Network Public Opinion Knowledge Base Group Interoperability Standards Information heterogeneity in multimedia network public opinion knowledge manifests in type, structure, syntax, and semantic differences. With numerous sub-databases forming a distributed storage framework, interoperability must address heterogeneity in both stored data and multi-platform data sources, which impact data exchange. Therefore, base group interoperability requires a series of recognized, commonly accepted protocol standards to integrate and connect sub-databases.

These standards should satisfy three conditions: (1) possess inherent interoperability; (2) allow sub-databases to establish metadata formats meeting their specific needs within protocol scopes; and (3) be operational, simple, flexible, and easy to follow [12]. Interoperability standards provide a unified input-output environment, enabling data-utilizing databases to acquire data from multiple provider databases through uniform interfaces. These standards allow sub-databases to transform between data service and data utilization roles, serving as both providers responding to information requests and recipients of data from other databases.

3.5 Multimedia Network Public Opinion Knowledge Base Group Scheduling Control Heterogeneous databases with independent management systems, operating systems, software, and data storage require top-level management systems to coordinate and schedule interoperability processes. Scheduling control systems manage the entire process from data input to

output, from data to information to knowledge, and control knowledge manipulation, querying, control, and mining. Specific functions include: centralized storage management of multimedia network public opinion knowledge, directory structure organization, document sorting, knowledge discovery and search control, information security assurance, and group permission management.

As a core interoperability element, scheduling control enables abstract information processing without requiring government regulatory departments to concern themselves with data layout and physical location in distributed frameworks. The system includes sub-database management systems responsible for: (1) managing and controlling databases to ensure security and integrity; (2) providing managers with schema decomposition and authority constraints; and (3) enabling append and delete operations on network opinion information.

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4. Multimedia Network Public Opinion Knowledge Base Group Interoperability Mechanisms and Relationships

Based on the interoperability process, this section examines mechanisms from seven perspectives: data aggregation, sub-database collaboration, scheduling control, algorithm matching, demand feedback, interactive service, and protocol adaptation.

4.1 Mechanisms of Big-Data Multimedia Network Public Opinion Knowledge Base Group Interoperability

4.1.1 Data Aggregation Mechanism Network opinion event information comprises diverse forms, types, platforms, and user data, describing events from content, attribute, and tag perspectives. Multi-state heterogeneous information resides in different architectural sub-databases, hindering knowledge discovery. Therefore, data must be clustered based on tags and characteristics, with similar event data aggregated into unified datasets stored in network opinion event databases to support subsequent information utilization. In practice, data volume and structure significantly impact table associations and value transmission across heterogeneous databases, with multiple cross-database associations impairing the efficiency of massive-scale interoperability and data utilization. The data aggregation mechanism is illustrated in [Figure 1: see original paper].

4.1.2 Sub-Database Collaboration Mechanism Multimedia network public opinion knowledge resides in knowledge bases while corresponding data is stored in databases. Transforming data into knowledge and enabling information transfer between sub-databases requires collaborative operations. Establishing equivalence between the reachable scope of mining databases built on data classification structures and the inference scope of knowledge base groups built

on inter-attribute relationships provides theoretical foundations for directed discovery and search, enabling information exchange between functionally different sub-databases. This is termed the sub-database collaboration mechanism.

In knowledge bases, knowledge nodes P = {$P_1P_2P_3$…P } maintain a peer mapping relationship with data classification structures S = {$S_1S_2S_3$…S } in databases. This mapping enables knowledge acquisition to transcend traditional limitations and access deeper-level knowledge. The collaboration mechanism effectively overcomes algorithm invalidation caused by massive data updates and difficulties in updating knowledge base group information, serving as the connection hub between databases and knowledge base groups. In practice, sub-database models and logical structures impact collaborative operations, with associations between item sets or object sets being influenced by database types and structures during correlation analysis. The sub-database collaboration mechanism is shown in [Figure 2: see original paper].

4.1.3 Scheduling Control Mechanism Rational resource allocation and interoperability among sub-databases in multimedia network public opinion knowledge base groups require participation from scheduling control systems. These systems must consider data volume, business volume, sub-database functions, and requirements to allocate resources effectively, maximizing efficiency during interoperability. Proper data distribution reduces response time and improves early warning and knowledge generation efficiency. The scheduling control mechanism organically organizes all elements and links of interoperability activities according to defined tasks, enabling effective operations. It monitors and controls the entire system, making judgments, decisions, and commands based on current status and anticipated changes.

During actual construction, scheduling control systems must consider existing sub-database construction patterns, frameworks, and rules while also accounting for standards for future expansions, requiring comprehensive long-term planning. The scheduling control mechanism is illustrated in [Figure 3: see original paper].

4.1.4 Algorithm Matching Mechanism Multimedia network public opinion knowledge base groups invoke heterogeneous data and match corresponding algorithms according to tasks such as crisis early warning, response, concurrent acquisition, and hotspot tracking. Different analysis algorithms exist for different data types: text similarity algorithms, text vector algorithms, and sentiment polarity algorithms for textual content [13]; image segmentation algorithms for pictures; audio preprocessing and feature extraction algorithms for sound; and shot segmentation and keyframe extraction algorithms for video content [14]. Matching appropriate algorithms enables reasonable knowledge discovery and mining, ensuring effective system functionality.

During interoperability, algorithm matching may encounter invalidation or require optimization for new data types, necessitating designers to optimize ex-

isting algorithms and add association algorithms based on requirements. The algorithm matching mechanism is shown in [Figure 4: see original paper].

4.1.5 Demand Feedback Mechanism Mining multimedia network public opinion knowledge to serve regulators represents the primary task of knowledge base group interoperability. Knowledge mining functions are configured according to regulatory requirements, which constantly evolve with changes in high-risk events and hotspots. This requires flexible adjustment of functional configurations and frameworks to adapt to various opinion events and shifting regulatory demands. Based on demand feedback, knowledge base groups adjust functional settings, data acquisition types and volumes, mining algorithms, and frameworks to provide comprehensive, multi-angle monitoring solutions and response mechanisms in real-time.

During interoperability, feedback-driven modifications may cause fundamental transformations in sub-database functions and structures, consequently affecting associated sub-databases' connection patterns. The demand feedback mechanism is illustrated in [Figure 5: see original paper].

4.1.6 Interactive Service Mechanism Comprising multiple types and functional sub-databases, multimedia network public opinion knowledge base groups require configuration and updating according to knowledge mining needs. Single matching operations limit efficiency and analytical effectiveness, making interactive services and multi-directional matching optimal for enhancing interoperability performance. For example, when a network opinion database serves as data provider, a case database acts as data user, receiving processed data to form case data. Conversely, case databases can provide cases for analysis, storing related data in databases. Sub-databases can both provide and receive services, with interactive services and mutual matching constituting the interoperability mechanism. The interactive service mechanism is shown in [Figure 6: see original paper].

4.1.7 Protocol Adaptation Mechanism The heterogeneity of multimedia network public opinion knowledge base groups features complex sources, heterogeneous types, and diverse formats from a data perspective, and heterogeneous storage, frameworks, and interfaces from a sub-database perspective. Therefore, interoperability requires establishing a series of interface configurations, metadata, and protocol standards to ensure orderly data transmission and information sharing. Data transmission involves protocols where data is encapsulated and unpacked layer-by-layer for transfer between sub-databases. Connection establishment relies on interface standards, with unified interfaces integrating heterogeneous sub-databases to provide data transmission environments. Unified metadata standards enable managers, developers, and applications to conveniently locate required data.

In practice, determining communication protocols, transmission protocols, and

interoperability standards for heterogeneous data presents challenges. The protocol adaptation mechanism is illustrated in [Figure 7: see original paper].

4.2 Relationships Among Interoperability Mechanisms

4.2.1 Relationship Between Elements and Mechanisms The data aggregation mechanism acts on multimedia network public opinion data as the first step in interoperability, initiating aggregation based on ontology concepts (i.e., events) after obtaining data flows. According to data type, format, and attributes, data is stored in corresponding databases as prerequisites for subsequent operations. The sub-database collaboration mechanism requires information sharing between sub-databases, involving algorithm invocation during transmission since mining algorithms are stored in algorithm repositories. Algorithm matching operates during knowledge mining, where network opinion data requires algorithmic support to generate knowledge correctly. The scheduling control mechanism acts on the group management system, coordinating the entire interoperability process as technical support. Demand feedback acts on sub-databases, which adjust functions and update based on feedback to ensure applicability across all stages of network opinion development. Protocol adaptation acts on data transmission processes, forming pathways between sub-databases and integrating the group into a unified whole. The relationship between elements and mechanisms is shown in [Figure 8: see original paper].

4.2.2 Relationship Between Processes and Mechanisms Structured data forms more highly correlated multimedia network public opinion ontology data through aggregation. Corresponding algorithms execute according to monitoring tasks, with result data stored in appropriate sub-databases as foundations for subsequent operations. The group control system manages storage control, interoperability standards, sub-database collaboration, and data transmission, ensuring safe and orderly interoperability. New data, cases, and knowledge generated through interoperability can be stored back into the group, enabling iterative knowledge updates and proliferation. Based on regulator feedback regarding functional configuration, improvement, and service requirements, the group updates and upgrades to optimize interoperability and enhance performance. The relationship among data aggregation, scheduling control, algorithm matching, protocol adaptation, interactive service, sub-database collaboration, and demand feedback mechanisms is illustrated in [Figure 9: see original paper].

4.2.3 Inter-Mechanism Relationships Sub-database collaboration, interactive service, and demand feedback mechanisms all act on sub-databases. Collaboration and interactive service mechanisms affect sub-databases through data and frameworks respectively, being interdependent and mutually influential. When data structures change, corresponding framework changes occur. These

two mechanisms ensure coordinated interoperability but may generate multi-threading issues, causing system redundancy or performance constraints that impact efficiency. Demand feedback adjusts and optimizes sub-databases based on results, also influencing scheduling control and algorithm matching mechanisms. The control system adjusts frameworks and updates systems according to feedback, while algorithms optimize accordingly. In practice, feedback demands require weight analysis, with secondary demands subordinating to primary ones. Data aggregation influences protocol adaptation, as interoperability processes must adjust or add communication, storage, and interoperability protocols based on actual file formats and types stored in sub-databases. Some file protocols or formats may be incompatible, requiring data and protocol standard conversions to ensure complete data-level interoperability.

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5. Conclusion

Based on the characteristics of multimedia network public opinion information, this study conducted in-depth research on the elements and mechanisms of knowledge base group interoperability, revealing distinct features compared to traditional knowledge base operation models. Integrating multimedia network public opinion data characteristics, we identified five interacting and complementary elements that constitute a comprehensive interoperability process. We subsequently analyzed process mechanisms from multiple perspectives, offering new insights for related research. This research provides technical support for network opinion regulation in the new Internet era, enabling regulatory departments to warn and respond to various network opinion emergencies rapidly, timely, and efficiently, thereby reducing crisis risks and monitoring costs. Future work will focus on improving interoperability efficiency and constructing comprehensive application models for multimedia network public opinion knowledge base groups.

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Author Contributions

Huang Wei: Framework and content guidance
Zhao Jiangyuan: Topic selection and writing
Xu Yejing: Data collection and organization, text proofreading

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