MISQ Research Curation on Data Management

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In our modern, digital world, the critical role of information technology makes data management an important research topic. This paper curates data management research at *MIS Quarterly* as it has progressed from its early context of understanding requirements of relatively simple information systems to the sophisticated and complex systems of today. In the following sections, we discuss the focus of this curation, the themes of data management, and the progression of research over time. We reviewed each paper published in MISQ since its inception, assessing the paper's relevance to the curation's theme. Because of the ubiquity of the word 'data' in MISQ papers, we performed this review manually rather than relying on keyword searches. We iteratively classified the relevant papers into 5 themes based on consensus. Our final curation includes 81 papers. To keep the text concise, we eschew citations from the paragraphs below and instead include them in the associated tables that follow.

1. Focus of Research Curation

Nearly all aspects of business and society are affected by initiatives involving the capture, storage, and use of data: artificial symbols that are employed to represent states of reality. With the increased reliance on digital data (symbols represented via binary code), the field of data management emerged in the 1970s: the same decade in which *MIS Quarterly* was launched. In fact, the first issue of the journal included a paper on data management. Since then, data management has become increasingly important. With organizations embarking on digital transformation programs, data has become a central driver of how organizations operate and are managed.

2. Themes of Data Management

We define the *field of data management* as an area of study that investigates and develops activities and methods to conceptualize, collect, curate, consume and control data to support insight, analysis, and action. We, thus, establish the 5Cs of Data Management, shown in Figure 1 and use them to classify the significant research that has been carried out in information systems, as reported in *MIS Quarterly*.

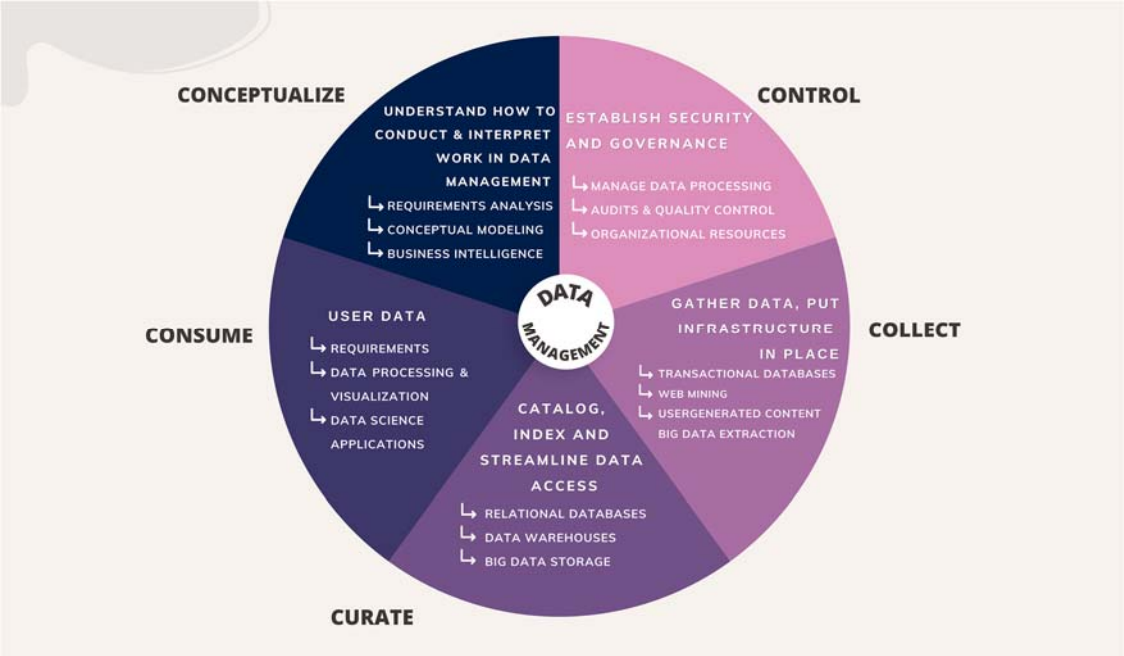

Figure 1. 5Cs of Data Management

2.1 Conceptualize

Conceptualization is an activity that analyzes and represents (e.g., using concepts such as conceptual schemas, relationships) an existing situation, problem, or process. In the information systems field, conceptualization research has focused on eliciting information requirements, defining the data creation process, and supporting the design and implementation of information technologies. The most prominent research has focused on developing methods for requirements elicitation and analysis, and developing and evaluating conceptual modeling approaches. The latter lies at the core of "conceptualize" because it enables the graphical representation of requirements identified through the requirements elicitation process. Conceptual modeling supports information systems development, especially database design and project management, by defining the scope of a system in terms of its data and functionality.

MIS Quarterly contributions to the "conceptualize" aspect of data management research began in the 70s and 80s and focused on ensuring that information systems meet the data requirements of their users, either through improving methods for requirements elicitation or by identifying specific information requirements. During the 1990s, there was a continued focus on identifying information requirements for specific roles as well as comparisons of various requirements elicitation methods and tools. The introdution of the world wide web led to research on hypertext databases. In the following decade, a shift within conceptualize-related research occurred, moving it towards developing and evaluating conceptual modeling notations and methods. In the last decade, *MIS Quarterly* has continued its consistent focus on conceptual modeling and saw the return of the identification of requirements for specific contexts or types of systems.

2.2 Collect

Collection is a data management activity to identify suitable sources of data, design data collection or data extraction and integration protocols, and establish quality and other controls over data collection and acquisition. Data collection may involve creating new data or acquiring existing data, such as extraction of data from a website. Major challenges and solutions related to data collection emerged in 1970s and 80s. The challenges of data collection focused on the needs of the emerging applications of technology, such as relational databases and electronic data interchange (EDI). Studies focused on supporting transaction processing, batch processing, and recording unanticipated ("special event") data. Issues of data collection gradually transitioned from a pure technological focus to an organizational imperative, supported by research on the costs related to poor data collection and the consequences of poor data collection practices.

In the 1990s, research continued to investigate data collection in transaction processing systems, but with greater emphasis on distributed processing. The next decade can be characterized by a focus on web technologies, their design and content extraction. With the rise of the world wide web, researchers started to consider challenges associated with ensuring high data quality, and collecting large amounts of data from customers on the Internet. Over the past decade, research continued to focus on the design of collection and extraction mechanisms of existing data on the Internet. With the increasing volume and societal value of user-generated content, research investigated the collection of varied and heterogeneous data from online users. Other studies continued to apply natural language processing techniques, increasingly supported by data intensive machine learning approaches, such as deep learning neural networks.

With the evolution of technologies and new methods to collect data, a parallel evolution of the roles related to data collection occurred. Thus, initially, data collection was a concern for database designers, auditors, and managers overseeing the process. With the diversification of data sources, many others began involved in data collection activities, including programmers and engineers tasked with extracting data from external sources, data scientists attempting to reuse existing data, and ordinary people, who are the providers of user generated content.

2.3 Curate

Curation, as a data management activity, involves the development of both physical and logical infrastructures that make it feasible to collect, index, and store data, and facilitate data access for subsequent analysis. The curation of data involves categorizing and organizing data so it can be easily shared. Specific activities include: designing data storage systems, such as databases; cleaning and transforming data to ensure it can be stored in existing data storage infrastructures (e.g., relational databases); cataloguing and indexing data to facilitate subsequent retrieval; and ensuring appropriate security of data storage systems. Data curation is dependent upon the goals for subsequent use. Various techniques and approaches convert data into a usable form and store it in data warehouses, so it can be used for a wide range of purposes.

Data curation research was active in 1970s and 80s, as storage challenges began to emerge, with a focus on the design and use of relational databases. Research also investigated security and protection of storage mediums. In the 1990s, the focus on relational databases continued, aimed

at incorporating greater domain semantics and making querying easier for users. New data storage technologies, such as data warehouses, continue to be studied. The recent focus on data science and data analytics has led to much work on machine learning, requiring large amounts of training and execution data.

2.4 Consume

Consumption is an activity that results from the application of data management principles and techniques, in which the data is analyzed and processed to answer questions, generate inferences, and draw insights. This phase involves tasks for preparing curated data so it becomes *ready for consumption*. The consumption includes preparation of curated data for analytics tasks, including assessing the quality of data before use, processing, and transformation. It may be supported by applications and techniques, including natural language processing (NLP), data mining, or machine learning. Important aspects of consumption are data re-representation and visualization.

With the introduction of online systems in the 2000s, research moved from supporting single decision-making tasks with structured data towards the development of applications for processing structured and unstructured data, independent of decision tasks. This data originates from traditional relational databases as well as from social media, log files, and technical reports. Preparation of structured, semi-structured and unstructured data for consumption by statistical methods including data mining became a focused topic in IS research. Recently, theory-driven research has started to pose constraints on preparation of data for consumption. Generally, data consumption has become more sophisticated in its data representation, visualization, transformation, and processing. Increasingly, mathematically formalized models with strong technical realizations are being investigated to allow for deeper insights into the datasets and better control of data usage in subsequent data analysis.

2.5 Control

Control is the activity that establishes security policies, institutes governance protocols, and aligns other activities of data management (the other Cs). It includes the legal, ethical, strategic, and other objectives and values of an organization. Techniques and approaches to control involve: establishing security rules and mechanisms of enforcement, institutional structures around data management, and monitoring and policing them to conform to organizational and higher-level mandates. Recognition of the need for effective control of data has led to the development of both technical and managerial techniques, including cryptography, blockchain, numerical analysis, separation of duties, and data audits.

The topic of control saw widespread focus in the 1980s, declined in the 1990s and became essentially non-existent in the 2000s. Early *MIS Quarterly* papers related to control explored the role of the data manager. Research in the 1980s to 1990s moved the discussion to the structure level, identifying which parts of the data management function should be centralized or decentralized. The conversation on these topics now has a wider scope, since research is no longer concerned with centralization or decentralization of data processing, but rather, with centralization or decentralization of overall information management functions. Today, the role of the data manager and how audits should be conducted have generally been formalized in standards, thus highlighting the importance of the data

management function. Research on control now takes a more holistic approach, recognizing that one does not control data management as much as one controls and manages the organizational resources. In this way, it becomes more aligned with the consumption of data and other organizational resources.

3. PROGRESSION OF RESEARCH

Significant research efforts in the evolution of data management are summarized in Table 1 and illustrated in Figure 2.

Table 1: Progression of Research Contributions

5Cs	1970s - 1980s	1990s	2000 - 2010	2011 - present
Conceptualize	Requirements elicitation & analysis approaches, specific information requirements, conceptual modeling notations and methods	Requirements elicitation, conceptual modeling methods and evaluations	Conceptual modeling methods and evaluations, ontological foundations	Conceptual modeling methods, representation theory, ontological foundations,
Collect	Transactional databases, EDI, batch processing	Transactional databases, distributed databases	Web mining, web content design	User generated content, social media, crowd sourcing, big data extraction
Curate	Relational databases, data warehouses,	Data warehouses, distributed environments	Data warehouses, social media, e-commerce, data integration	Big data storage; longitudinal, dynamic data
Consume	Data requirements, managerial perspective, query languages	Factor analysis, data transformation	Data visualization, web data	Data science, big data processing
Control	Manage data processing, cryptography	EDI audits, quality, integrity, security	Subsumed under organizational resources	Subsumed under organizational resources

4. CONCLUSION

Data management has progressed from traditional transaction processing to become a major organizational asset and basis for decision-making in society. With continued automated capture, increasing processing capabilities, and transmission of large amounts of data in multiple data formats, this topic will, undoubtedly, continue increasing in importance. This curation reflects the vast work on data management that has been carried out as the field of information systems has progressed. The research is organized around the themes identified as the *5Cs of Data Management*. Of the five themes, conceptualize has been researched the most consistently over time, whereas the other four have evolved in different ways. More generally, the themes reflected the evolution of information technologies and changing interests and priorities of organizations.

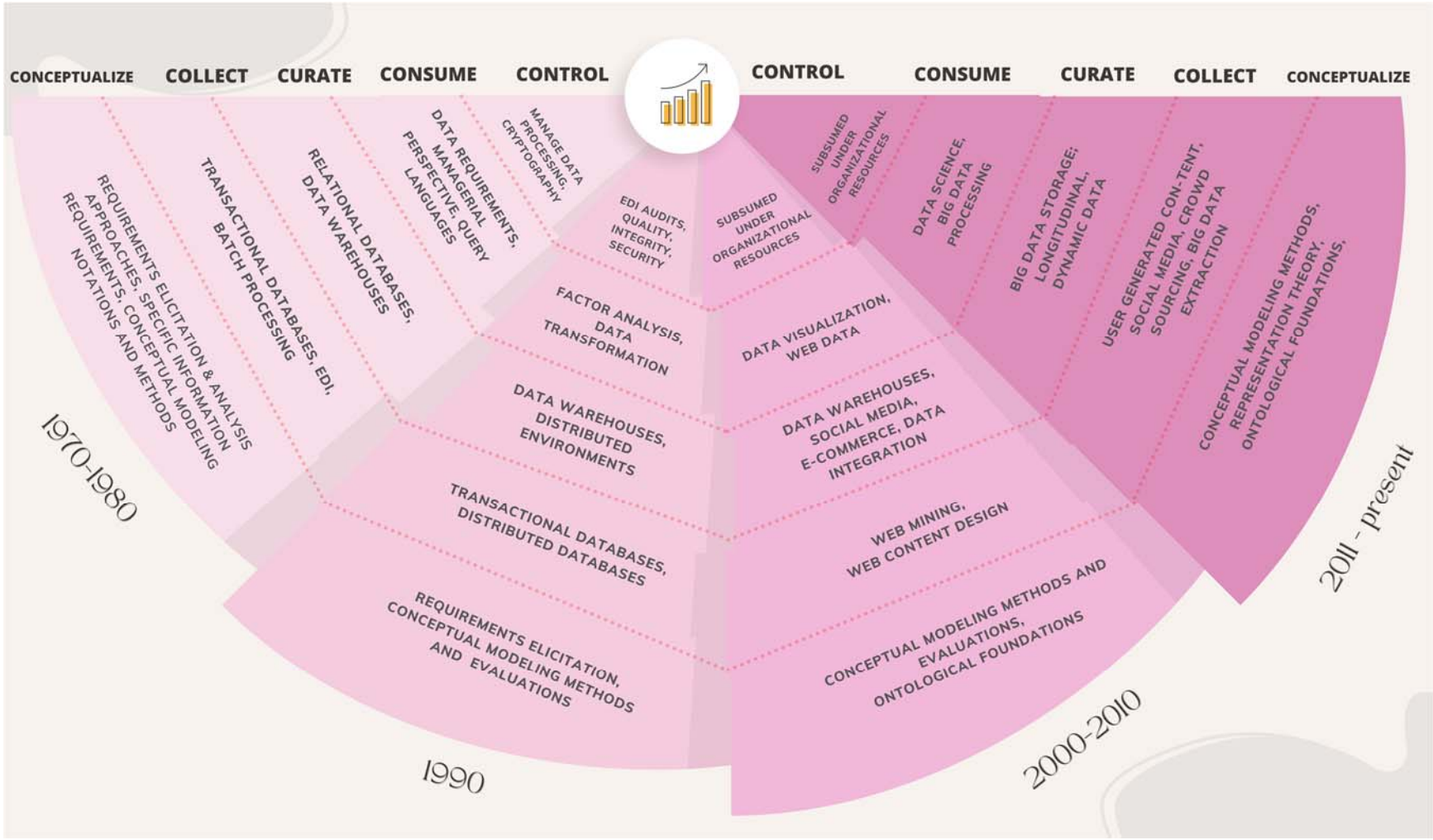

Figure 2. Progression of Data Management

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