Big Data Fabric Architecture: How Big Data and Data Management Frameworks Converge to Bring a New Generation of Competitive Advantage for Enterprises

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Abstract

Big Data Fabric Architecture is a derivative of multiple stages of big data, and data management frameworks and architecture, which converged several different components of emerging technologies to help large businesses effectively manage their data. These emerging technology components such as big data analytics and cloud computing are the building blocks of the newest and latest form of big-data enterprise architecture. Large businesses can achieve competitive advantage through differentiation of enterprise systems and the deployment of big data analytics. Big Data Fabric Architecture offers business-focused solutions to data management problems. It also increases the ability to generate value from effective big data analytics, which delivers actionable business insights. This study proposes a new framework to ensure that the effectiveness of Big Data Fabric Architecture and its competitive advantage can be realized, whilst taking into consideration the existing cases of similar architecture, and its associated challenges. Finally, given this architecture's recent emergence, specific deployment examples and application of Big Data Fabric Architecture are still immature in industry practice. Research on Big Data Fabric Architecture is currently limited; therefore, much is to be benefited from conducting further studies into how this architecture can increase competitive advantage in enterprises.

1. Introduction

The purpose of this study is to investigate whether the emerging technology of Big Data Fabric Architecture and its implementation can bring an organization competitive advantage in their industry. The need to investigate this arises from studies showing that the widespread adoption and investment of various enterprise systems can only bring large businesses competitive advantage in the short-term (Collis & Montgomery 1995; Porter & Millar 1985). The temporary competitive advantage of investments of enterprise systems are attributed to the Resource-based View (RBV) principle, in that if all other organizations adopted the same IT systems, then differentiation factors such as strategic resources are lost, and competitive advantage is diminished in the long-run (Collis & Montgomery 1995).

This study seeks to understand the following question: How can the implementation of Big Data Fabric Architecture in enterprises influence their competitive advantage?

2. Big Data Fabric Architecture

Big Data Fabric Architecture's origin ultimately stems from a business need to effectively manage big data, as shown in Figure 1. As the architecture is business-focused, there is much anticipation for its ability to gain competitive advantage as the architecture works purposely to serve business needs.

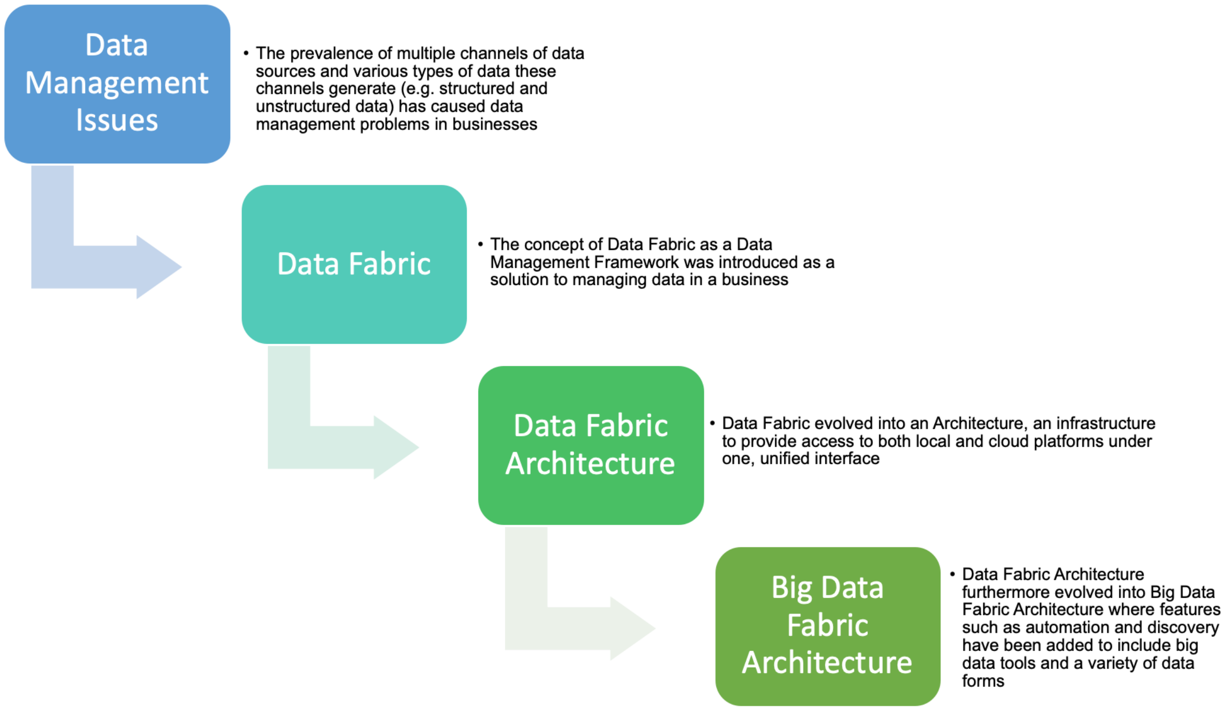


Figure 1. Building Blocks of Big Data Fabric Architecture. Data Management Issues from McDaniel (2019), Data Fabric from Raza (2018), Data Fabric Architecture from Morrell (2017), Big Data Fabric Architecture from Yuhanna, Leganza, Warrier, and Izzi (2016).

2.1. Elusive Benefits of Big Data Fabric Architecture

Big Data Fabric Architecture was proposed to not only manage data, but to generate extractable, useful information from the data and turn it into actionable business insights, without the complication of multi-platform sources and integration issues that are prevalent with current enterprise architecture trends (Yuhanna et al. 2016; Yuhanna & Istok 2017). As shown in Figure 2, Big Data Fabric Architecture rests on the foundation of the following emerging technologies that have been respectively known to generate their own respective forms of competitive advantage: Big Data Analytics, Cloud Computing, and Data Fabric Architecture.

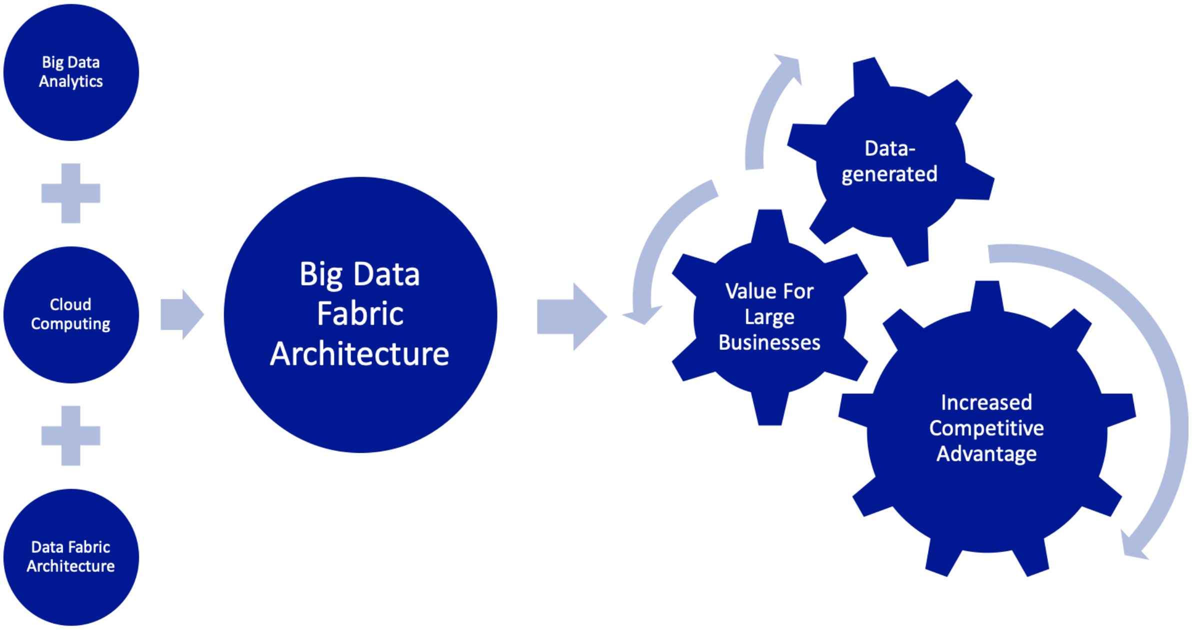


Figure 2. Elements that comprise Big Data Fabric Architecture to generate new competitive advantage.

2.2. Big Data Fabric

Big Data Fabric is a compound word coined by Yuhanna et al. (2016) and combines technical elements from 'Big Data' and 'Data Fabric'. The difference is that Data Fabric does not guarantee big data in its data management framework. The convergence of these two existing technologies creates the foundation from which the term Big Data Fabric is built. The formal definition of Big Data Fabric is "bringing together disparate big data sources automatically, intelligently, and securely and processing them in a big data platform technology, using data lakes, Hadoop®[1], and Apache Spark™[2] to deliver a unified, trusted, and comprehensive view of customer and business data" (Dooley 2018; Yuhanna & Istok 2017).

[1] Apache Hadoop is a registered trademark of the Apache Software Foundation.
[2] Apache Spark is a registered trademark of the Apache Software Foundation.

2.3. Big Data Fabric Architecture Layers

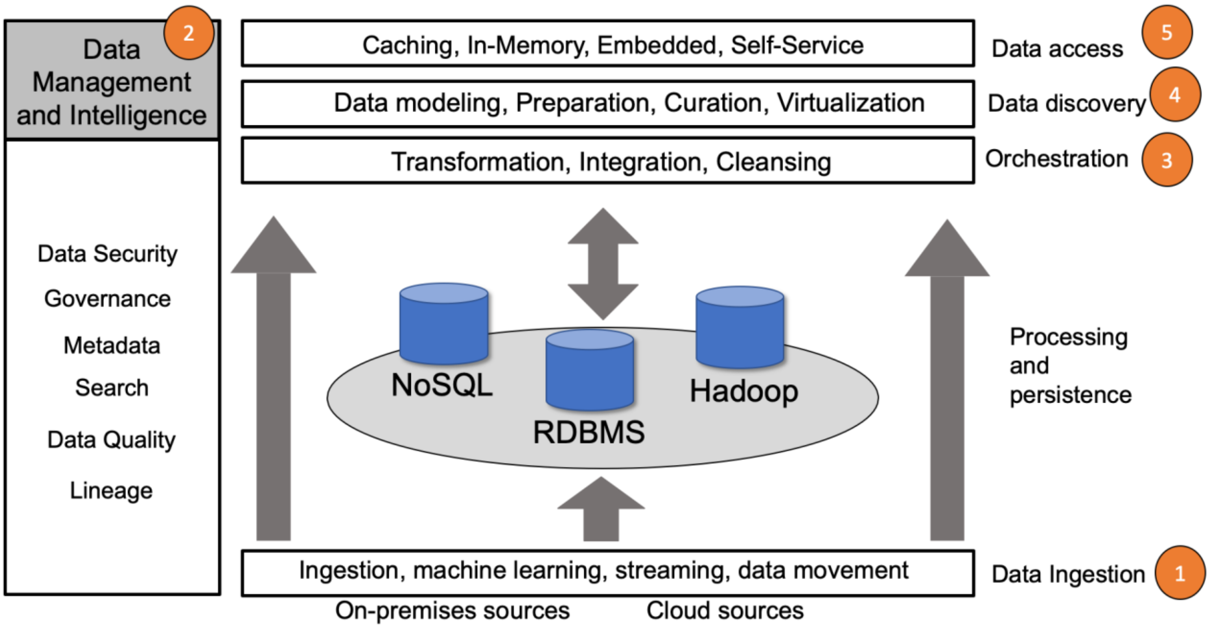


Figure 3. Big Data Fabric Architecture. From "Big Data Fabric Drives Innovation and Growth," by N Yuhanna et al., 2016, *Forrester Research.* Copyright 2016 by Forrester Research.

Big Data Fabric Architecture, as shown in Figure 3, is comprised of Big Data analytical tools and the following 5 layers (Moxon 2018):

1. Data Ingestion: Data is loaded into big data repositories.
2. Data Management and Intelligence: How data is being governed, secured, managed, accessed, and other related processes.
3. Orchestration: Data is integrated and transformed into meaningful information that is consumable by the users.
4. Data Discovery: The available data that users can see.
5. Data Access: An interface for users to access and get data to obtain business insights.

2.3.1. Layer 1: Data Ingestion

Data ingestion gathers data and brings it into the data processing systems. This layer processes incoming data, prioritizing sources, validating data, and routes it to the best location for storage after which the data is available for use. Data extraction can happen in a single, large batch or broken into multiple smaller ones. The data ingestion layer will choose the method based on the situation, prioritizing a faster loading time optimized for the program (John & Misra 2017).

2.3.2. Layer 2: Data Management and Intelligence

Data Management and Intelligence is interwoven across all other layers in the architecture to ensure consistency and uniformity of data security, metadata management, data governance, compliance, internal policies, external policies, and data quality across the entire data process, regardless of the data's database or origins (Hassell 2018; Moxon 2018).

2.3.3. Layer 3: Data Orchestration

Data orchestration is a relatively new concept to describe the set of technologies that provides an abstract for data access across storage systems, virtualizes all the data, and presents the data via standardized APIs with a global namespace to data-driven applications (Bakshi 2011, p. 4; Diederich 2019).

2.3.4. Layer 4: Data Discovery

Data discovery is the business user driven and iterative process of discovering patterns and outliers in data (BARC Research 2017). Data discovery requires skills from business analysts in understanding data relationships and data modeling, as well as in using data analysis and guided advanced analytics functions to reveal insights (BARC Research 2017).

2.3.5. Layer 5: Data Access

Data Access is, in its basic form, code that web developers write to interact with the data source and is tailored to business-specific implementations (Patton 2006). With this customized code, Data Access Layer retrieves and modifies data from the databases by connecting to the database, open and close connections, and executive CRUD (Create, Read, Update, and Delete) operations (Kanjilal 2015).

2.4. Big Data Analytics and Cloud Computing

Big Data Analytics is a process of collecting and managing data to allow for business analytics to generate meaningful observations and insights, as shown in Figure 4.

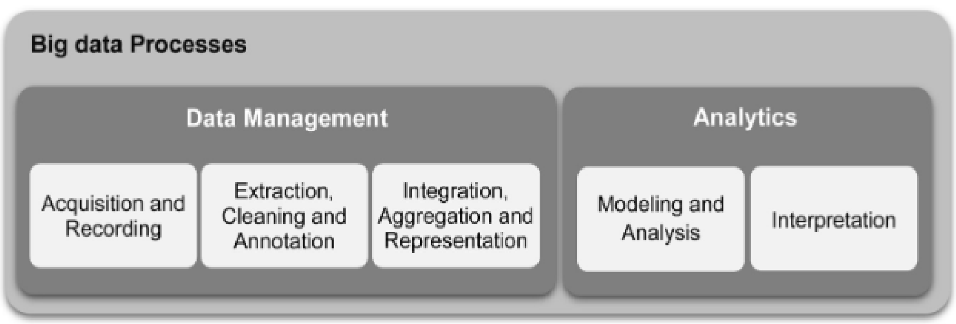


Figure 4. Understanding the structure and role of Big Data Analytics. From "Beyond the hype: Big data concepts, methods, and analytics," by A Gandomi, & M Haider, 2015, *International Journal of Information Management, 35,* p. 141. Copyright 2015 by International Journal of Information Management.

Big Data Analytics can only be made possible through the platform of cloud computing. As local hardware are incapable of processing data over one terabyte, such as big data, vendors such as Microsoft or Amazon offer a service called Infrastructure as a Service (IaaS) where the infrastructure uses the computational power of cloud computing, instead of local hardware, to generate, collect, and store big data (Bakshi 2011; Schroeck, Shockley, Smart, Romero Morales, & Tufano 2012).

Big Data Fabric Architecture also allows for one unified platform (refer to Figure 3) that provides one interface to view the consolidated data from various cloud computing and local platforms and its associated databases. This culminates in establishing a more holistic single version of truth in the data they are producing (Pearlman 2019), thus generating a new form of competitive advantage not previously utilized.

2.5. Limitations with Data Fabric Architecture

Data Fabric Architecture is the predecessor of Big Data Fabric Architecture, however due to its limitations, it can be deemed as an inferior option to gaining competitive advantage. Table 1 summarizes capabilities that Big Data Fabric has compared to Data Fabric. As shown in Figure 5, Data Fabric Architecture does not contain big data-driven value capabilities. Since Big Data Fabric is more capable of delivering higher value from extracted data to generate actionable business insights, large businesses should focus on achieving Big Data Fabric Architecture over its available predecessor.

Table 1.
Differences with Big Data Fabric and Data Fabric.

Big Data Fabric	**Data Fabric**
Ability to handle various types of data	Can only handle structured data
Real-time Analytics	Majority of data are batch-processed
Ability to integrate different big data analytical tools (e.g. Hadoop and RDBMS, despite their differences, the infrastructure can still integrate the two tools)	If analytical tools cannot talk to each other, then tools cannot be integrated

Note. Information for Big Data Fabric from Foote (2019) and Information for Data Fabric from Yuhanna and Istok (2017).

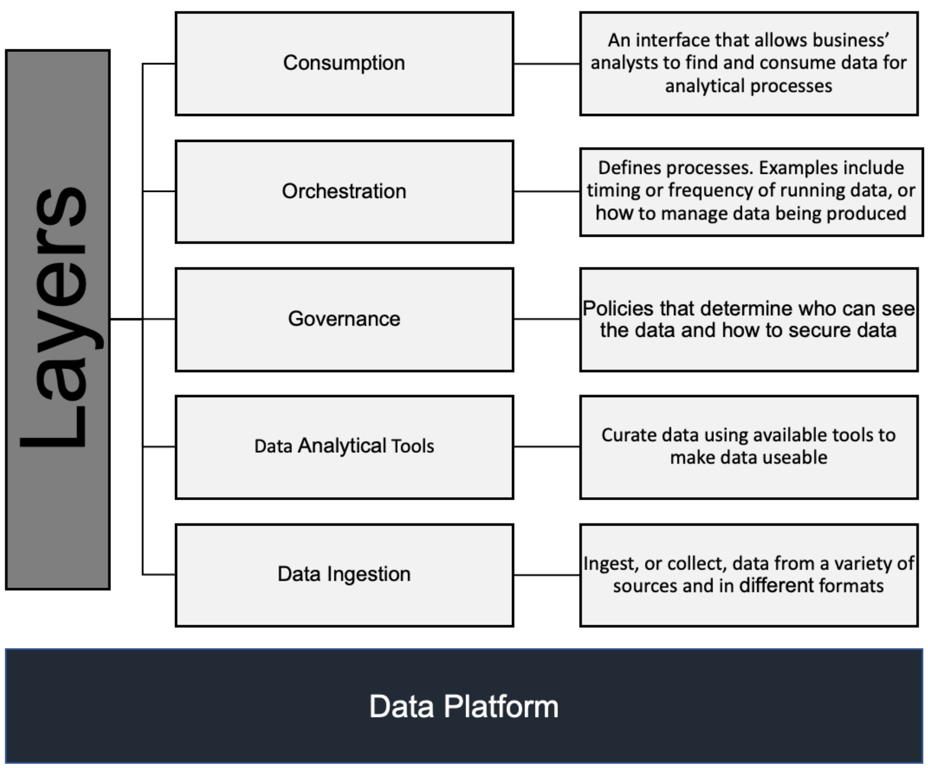


Figure 5. Data Fabric Architecture. Adapted from Secrets to Utilizing a Data Fabric. Retrieved from https://www.dataversity.net/secrets-utilizing-data-fabric/. Copyright 2018 by John Morrell.

3. Competitive Advantage and Enterprise Systems

Studies have shown that IT systems, data, and information are crucial elements that have been proven to increase an organization's competitive advantage through the ability of achieving the five competitive forces as shown in Figure 6. Due to the rise of the big data revolution, collecting data and generating valuable information is one of the latest principal business strategies to gain competitive advantage (Lohr 2016; Porter & Millar 1985). Therefore, adopting an enterprise architecture that can differentiate a large business from its competitors is paramount to achieving competitive advantage (Collis & Montgomery 1995).

Figure 6. The five competitive forces that shape strategy and industry competition. From "The Five Competitive Forces That Shape Strategy,' by M. E. Porter, 2008, *Harvard Business Review, 86,* p. 80. Copyright 2008 by M. E. Porter.

3.1. Past, Present, and Future Trends of Enterprise Architectures

Enterprise Systems such as an Enterprise Resource Planning (ERP) system or Customer Relationship Management (CRM) system have been a past trend that have proven results in generating competitive advantage through data integration, process differentiation, and data automation (Davenport, Thomas, Harris Jeanne, & Cantrell 2004; Turban & Volonino 2010, pp. 301-332).

Currently, the trend is to switch to hybrid infrastructures where enterprises use both local and cloud-based platforms to achieve competitive advantage through increased efficiency, reduced IT expenses, and generating real-time data for analysis (Michael 2014, p. 579; Xiang, Schwartz, Gerdes & Uysal 2015, p. 121). However, because hybrid platforms inevitably generate big data, enterprises are challenged with managing big data effectively, resulting in extensive data management issues (Zikopoulos & IBM 2011; Porter & Millar 1985, p. 7).

Moreover, studies have shown that only 25% of data in enterprises are being used for analytics (Yuhanna & Istok 2017). Whilst the current trend has been towards benefits from cloud-based platforms, the opportunity is currently wide open for large businesses to zone into the vastly uncaptured and largely unutilized method of effectively extracting value from big data, and turning them into actionable insights, thus gaining a new generation of competitive advantage.

4. Case Analyses

4.1. Organizations using Big Data Analytics to Gain Competitive Advantage

From a technical point of view, big data is different from traditional data resulting from transactions. Therefore, it requires new data management and analysis tools. Research conducted by Ylijoki and Porras (2016) uses Google and Amazon as examples to suggest that companies who utilize data tend to heavily gain competitive advantage over their competitors that are less data driven. The volume, variety and velocity of big data can pose challenges for data management technology and the key to gain valuable insights is to apply proper analytics tools to the big data (Ylijoki & Porras 2016).

Netflix, as a top online streaming service provider, has utilized big data analytics since 2006. The primary objective for Netflix is to provide users with a better recommendation system using big data analytics (Maddodi & K 2019). The recommendation system able to achieve a high level of accuracy based on user preference through two separate data collection systems:

1. Content-based filtering collects previous watching history of the subscriber, and
2. Collaborative filtering based on similar user profiles.

Netflix was able to build a hybrid recommendation system that combined both content-based filtering and collaborative filtering. The company also adapts Amazon web service cloud computing platform to help it discover customer insight and manage customer's data. The scalability and agility offered by cloud computing ensure Netflix successfully provides content to millions of customers around the globe.

4.2. Organizations Using Data Fabric to Gain Competitive Advantage

The implementation of data fabric allows organizations to speed up the digital transformation and the key to innovation is powered by advanced enterprise architecture. Data-driven organizations have a natural competitive edge when it comes to sensing the markets, responding to customers, anticipating cyberthreats, and optimizing their processes (Baer 2018). Service providers such as NetApp and Winshuttle deploy data fabric architectures to enterprises in aid to help the organization to process, manage, analyze and store data from a multitude of sources.

Dominos, a globally known pizza company, have conducted digital transformation through the adaption of Data Fabric Architecture (Talend 2020). The goal for Dominos is to integrate data from every channel and to generate a single view of its operation. With data fabric, Dominos is able to build a data collection system that tracks from all the point of sale systems, supply chain centres and through all other advertising channels. Ducati is another company that utilises Data Fabric Architecture to achieve competitive advantage in the motorcycle industry (NetApp 2020). Ducati meticulously produced only 55,000 motorcycles in 2018. Compared with industry competitors that have production capacity in the millions, Ducati visioned itself to gain competitive advantage through a fast innovation capability. Therefore, the company treats data as a crucial part in terms of accelerating its success. By moving the data to a hybrid cloud platform, Ducati able to collect and analyse that data from more than 15,000 motorcycles across the world, which greatly boosts its information transformation speed from the road to product innovation. The capabilities of data fabric are the main reason that allow enterprises to gain competitive advantage. Some of key capabilities are:

1. Digital Asset Management

Data fabric simplifies the process of storing, processing and managing different forms of data. It also fosters the compliance and correct usage of digital assets. Moreover, the speed to organize and locate digital assets can be significantly improved, while the redundant storage and financial cost can be reduced.

2. Dynamic data model

This capability offers enterprises with flexible and extensible data models. It allows organizations to access and manipulate information without affecting the core data. In relation to new opportunities and competitions, dynamic data models can also flexibly evolve with changes in business requirements.

5. Remaining Challenges

5.1. Challenge 1: Management Decision-making and Action

Many organizations do not realize that the analytical capabilities enabled by big data fabric are not directly related to business benefits alone. It is through the conjunction of organizational processes and human decision-making that value can be attained by using a data-centric architecture (Shanks & Sharma 2011). Therefore, to fully realize the benefits from big data fabric, business management should play key roles in value-creation and decision-making processes, to understand the insights generated from big data analytics, identify potential opportunities, orchestrate resources and turn these insights into actions to help their organizations achieve key business objectives (Shanks & Sharma 2011).

5.2. Challenge 2: Data Integrity

Since data is one of the most important assets for enterprises, it is essential for organizations to maintain the quality of data. Repercussions of bad data will waste time, increase expenses, decrease productivity, and weaken decision-making (Nagle, Redman & Sammon 2017). There is still a challenge for large businesses to assure data integrity while implementing big data fabric, as a large portion of the enormous amount of big data might be outdated, incorrect, duplicated and incomplete (Barton 2019). Currently, only 3% of the organizations meet data quality standards (Nagle, Redman & Sammon 2017).

5.3. Challenge 3: Continuous Good Data Management Practice

While data fabric architecture provides a solution for data management, the increasing proliferation of data and the lack of good data management practices is a critical challenge for many large businesses. Data management is a group of practices that consists of the planning, development, implementation and administration of a system that uses data in a secure and efficient way (Office of the Deputy Prime Minister 2020). Research conducted by Vidgen, Shaw and Grant (2017) shows that managing data quality, security and privacy is still a major issue to enterprises. The challenge still remains to ensure improvements in developing strategies and policies relating to data security, decision-making processes, data governance, and data management practices (Rifaie, Alhajj, & Ridley 2009).

6. A Proposed Framework for Generating Competitive Advantage with Big Data Fabric Architecture

The challenges make it apparent that a new generation of competitive advantage from Big Data Fabric Architecture is reliant upon the effectiveness of value being driven from big data, by being able to extract data accurately and turn them into **actionable** business insights (Riahi & Riahi 2018).

Therefore, to ensure that competitive advantage is gained through the adoption of Big Data Fabric Architecture, this paper proposes a framework that incorporates **four principles** regarding maximizing value from big data analysis (Begoli & Horey 2012), and **three principles** regarding effective big data governance (Malik 2013). This proposed framework and its composed elements work interconnectedly to capture critical objectives in a business. The proposed framework also helps to achieve value driven by big data, thus providing a framework by which competitive advantage can be achieved through Big Data Fabric Architecture.

6.1.1. Support a Variety of Analysis Methods.

In order to generate value from data in a large business, during the process of knowledge discovery, organizations should apply a wide range of different tools and analysis methods (Begoli & Horey 2012). This will employ a variety of techniques and tools to collect big data, such as statistical analysis, data mining and machine learning, data visualization, and visual analysis (Begoli & Horey 2012). Having a large business employ a variety of analysis methods will bring a more comprehensive understanding of their data and thus be able to generate greater actionable insights.

6.1.2. One Size Does Not Fit All

Case studies have shown that a single style database such as a large relational database cannot meet all of the requirements from different types of analysis methods and structures of big data (Begoli & Horey 2012). Therefore, in order to gain value from data and turn these into actionable insights, a specialized data management system should be deployed. This will help large businesses effectively store, organize and manage vast stores of various types of big data, and to perform different types of analysis (Mousanif et al. 2014).

6.1.3. Data Security Management

The storing, access and processing of vast amounts of data enabled by big data fabric can bring potential security and privacy threats for organizations (Dooley 2018). Therefore, organizations should establish a common security standard based on the relevant regulations and privacy policies across the entire big data fabric, systems and platforms. This will make sure data is securely collected, stored and transmitted to protect data security and meet compliance requirements (McSweeney 2019). It is also necessary to establish an access control, which only allows authorized people to access big data, and update data with a proper audit trail (McSweeney 2019).

6.1.4. Make Data Accessible

Accessible data for business users is critical in achieving goals. Therefore, it is imperative to make data effectively accessible by users to ensure highly summarized data and turn into actionable insights (Begoli & Horey 2012). Disparate systems should communicate with a standard protocol to quickly present the results to users and have a flexible method to enable users to interact with data systems, such as using web-enabled APIs to visualize analytics results (Begoli & Horey 2012).

6.1.5. Engage organization, processes and people

Since Big Data Fabric Architecture enables data exchange in multiple cloud platforms and disparate systems **across the whole enterprise**, the successful implementation of Big Data Fabric Architecture requires the engagement of the three main elements: people, processes, and organization (Malik 2013). To gain competitive advantages by implementing big data fabric, it is essential to understand the enterprise's business strategies and business processes.

To fully realize the benefits from big data fabric, the organizations might need to **re-engineer business processes** to extract business values from unstructured and semi-structured data as traditional business processes only fit the structured data (Jha, Jha & O'Brien 2016). By redesigning the core business processes, organizations can gain thorough insights of their operations and quickly make responses while facing dramatic changes (Jha, Jha & O'Brien 2016). In this way, the design of Big Data Fabric Architecture can align with the organization's business strategies, objectives and needs, to **achieve business-IT alignment** and help organizations generate valuable insights to support better decision-making (Luftman 2000).

Moreover, organizations and people should be on the same page to construct a comprehensive big data fabric (Ansyori, Qodarsih, & Soewito 2018). Therefore, it is necessary to have **training** for the management and employees to take full advantage of big data fabric, which includes detailed knowledge of big data fabric, relevant guidelines, procedures and requirements for use. Besides this, and to ease organizational transition, it should also involve **change management** to help employees understand and accept the new big data fabric (Dilnutt 2005).

6.1.6. Set clear policies and standards

The Big Data Fabric Architecture enables organizations to deal with a vast amount of data from both inside and outside of the enterprise. With extremely high volume of data generation and exchange, it should involve the key stakeholders from the whole enterprise, and establish **a set of common standards and policies** to ensure **compatibility, integrity and integration** of data across multiple applications, systems and platforms (Boh & Yellin 2006). Also, the interactions between the different layers of Big Data Fabric Architecture should be standardized to enable continuous monitoring and a proven track of its performance (McSweeney 2019).

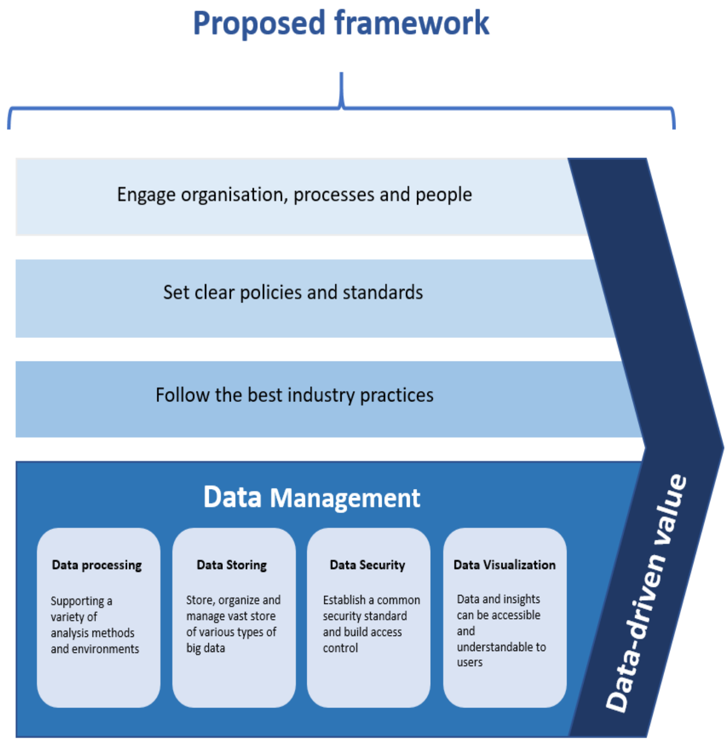
The organization can establish the standards and policies by considering three principles: modify and update the policies in an agile manner, transparent constructing process, and implement suitable existing criteria (Larno, Seppänen, & Nurmi 2019). With thorough standards and policies, the Big Data Fabric Architecture can help the organization effectively process the big data in good order, and eliminate the potential risks and errors to the maximum extent.

6.1.7. Follow the best industry practices

Since big data fabric is an emerging technology, the organization might face multiple practical implementation challenges. To successfully implement a Big Data Fabric Architecture, organizations need to **follow the best practices** which are commonly accepted by the industry, and has proven to lead to an implementation success (Malik 2013; Abunadi 2019). By following best practices, organizations can address underlying technical difficulties. This can minimize the potential risks, such as the existence of conflicting frameworks and business needs, to ensure the successful implementation of the project (Abunadi 2019). It can also help organizations to effectively direct their efforts to achieve their strategic goals, and make sure that the design of big data fabric has a comprehensive coverage of the whole enterprise. The organization can set its practice, such as integrating the business process, in order to enhance information interoperability, and using the cloud for information sharing across different units to strengthen collaboration, as well as using technological competencies to optimize the utilization of the organizational resources (Abunadi 2019).

6.2. Proposed Framework

The proposed framework to ensure competitive advantage is achieved through Big Data Fabric Architecture is shown in Figure 7.



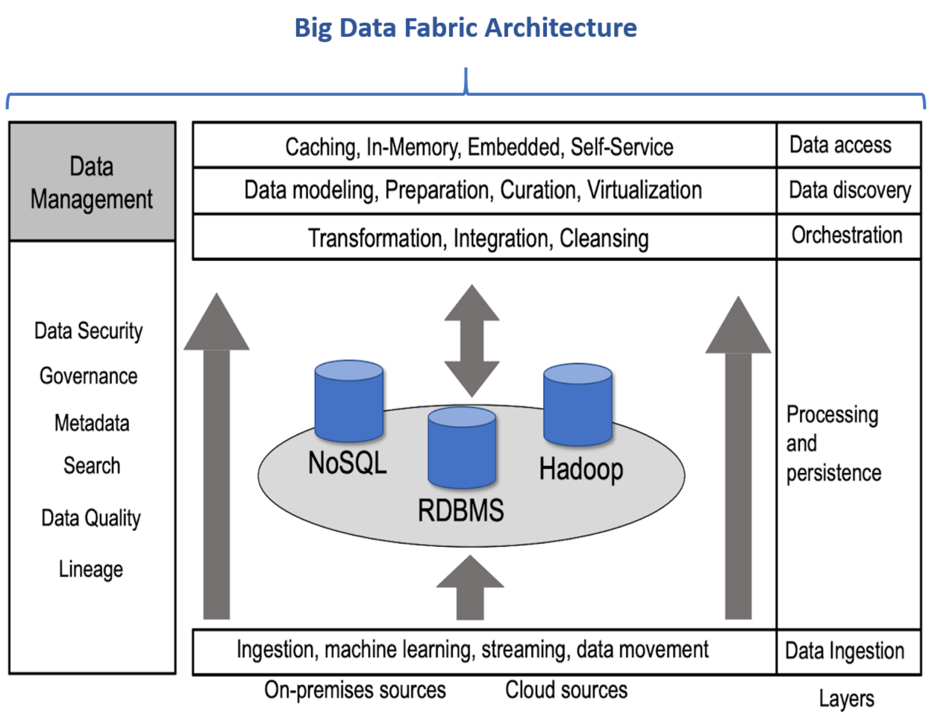


Figure 7. Proposed framework to achieving competitive advantage through big data fabric architecture.

7. Conclusion

This paper has found that Big Data Fabric Architecture is advantageous in its technical underpinnings, but it is through the combination with non-technical factors, such as continuous good data management and clear data strategies, that serve to be the keys to success in achieving competitive advantage. Moreover, competitive advantage is most effective when enterprises turn data-generated insights and observations into actionable decision-making. With these findings, this paper has proposed a framework, as shown in Figure 7, which consists of elements that work together to ensure that competitive advantage is achieved through Big Data Fabric Architecture for enterprises.

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