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Original Article

A New Pattern for Managing Massive Datasets in the Enterprise through Data Fabric and Data Mesh

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Abstract - The increasing volume and complexity of corporate data have revealed that traditional designs are not good enough for managing scalability, governance, and flexibility. This has led to the need for new solutions like Data Fabric and Data Mesh. Data Fabric focuses on creating a unified, automated architecture that connects data across hybrid and multi-cloud environments. This ensures smooth integration, strict control & easy access for users. Automating workflows lowers expenses & makes sure that the information is too accurate and follows the rules. On the other hand, Data Mesh moves to a decentralized structure where domain teams control the information and regard it as a product. This strategy uses self-service platforms & specialized expertise to make teams more flexible, creative & more cooperative. This lets them manage their data better without having to rely on their centralized limits. Both paradigms deal with these important problems in modern data management, but their actual value comes from how well they work together. This article looks at the basic principles, architectural features & ways to put both paradigms into practice, giving us a sense of how they may work in these business settings. This shows that combining Data Fabric with Data Mesh creates an architecture that can grow, change & be used by everyone, allowing businesses to derive greater value from huge datasets while still meeting the demands of the market.

Keywords - Data Fabric, Data Mesh, Enterprise Data Management, Big Data, Decentralized Data, Data Governance, Data Architecture, Hybrid Cloud, Data Democratization, Data Integration, Data Scalability, Metadata Management, Federated Governance, Data as a Product, Self-Service Platforms, Data Ownership, Automation, Data Interoperability, Data Lineage, Data Quality, Real-Time Analytics, Data Orchestration, Domain-Driven Design, Compliance, Security, AI-Driven Insights, Cloud-Native Tools.

1. Introduction

Data is the backbone of these modern businesses. It helps them make decisions, encourages the latest ideas, and makes their operations more efficient. The growth of IoT devices, social networking sites, transactional systems & business apps is making the amount & the complexity of information grow at an incredible pace. Companies that want to stay competitive are finding it hard to manage huge datasets well. However, traditional ways of managing their information, including centralized data warehouses and data lakes, frequently don't satisfy the changing needs of these modern businesses. Centralized systems have their own problems, even if they may be helpful in many other situations. When they grow to handle different, spread-out data sources, they typically cause bottlenecks. Furthermore, these technologies might keep data silos going, making it harder for data to be shared & accessed across many company boundaries. Governance is a big problem because businesses are trying to balance making data easy to access with following security & legal rules. These issues make it clear that we need to modify the way we handle and utilize our organization's data assets.

Data Fabric and Data Mesh are two latest technologies that may help with these kinds of problems. Both paradigms try to fix the problems with these traditional systems, but they do it from different angles, which makes them very complementary. Data Fabric is a way of building things that puts a lot of emphasis on making sure that the information from different sources can operate together without any other problems. It makes a single layer that combines and improves data from many different systems, so that businesses may access and analyze their information without worrying about how complicated it is. Data Fabric helps businesses make the most of their existing data assets and improve their operations. Data Mesh changes the way we think about data governance by making it less centralized. Data Mesh lets each domain team take care of its own data instead of relying on a single, central system. These teams treat data like a product, making sure that information can be found, is reliable, and can be used by others. This strategy eases the burden on their centralized IT workers and encourages the latest ideas by giving domain specialists control over their data and its insights.

1.1. The Basic Ideas behind Data Fabric

Data Fabric focuses on seamless integration, which lets businesses combine data from many other different sources without having to copy or move it. It makes it easier to find and retrieve information by using metadata and advanced analytics.

1.2. The Move to Data Mesh

Data Mesh gives domain teams control of information, which decentralizes data governance. This strategy treats data like a product, which encourages accountability & gives teams the capacity to offer high-quality, relevant information.

Figure 1. Converging Architectures: Data Fabric and Data Mesh for Intelligent Data Integration and Governance

1.3. How These Paradigms Work Together

Data Fabric and Data Mesh deal with different but related issues. Data Fabric provides the framework for integration, & Data Mesh makes sure that data governance and usability are part of particular teams, making it a complete solution for these modern businesses.

2. Understanding Data Fabric

Data Fabric is a collection of services and an architecture that work together to manage and combine different datasets in a distributed framework. Data Fabric provides a structured and unified way to handle data as companies deal with large datasets that are spread out over multiple systems, locations, and platforms. We look at its most important parts and how they work together to understand why it is such an important part of modern business data strategy.

2.1. What is Data Fabric made out of?

Data Fabric is a way to manage data that brings together different data sources, no matter where they are, what format they are in, or what platform they are on, to create a single, cohesive ecosystem. By making data silos easier to understand, it helps businesses harness the value of their data efficiently and consistently.

2.1.1. Basic Ideas behind Data Fabric

Here are the main theories underlying Data Fabric:

- Unified Data Access: Data Fabric gives you one clear way to get to and analyze data on both hybrid and multi-cloud systems.
- Scalability and Flexibility: It can grow with the company and handle more and different kinds of data without major changes to the architecture.
- Automation and Intelligence: Data Fabric uses automation to reduce the need for people to be involved in data integration and management tasks. Integrated intelligence makes data governance and operations more effective.

2.1.2. Main Features of Data Fabric

Data Fabric is characterized by its strong traits:

- Architecture Based on Metadata: A metadata layer makes sure that data can be found, understood, and used by everyone in the firm.
- Interoperability: Makes it easier for older systems, newer apps, and cloud services to work together.
- Security and Governance: Sets up rules for data security, compliance, and governance that apply to the whole enterprise.

2.2. How Data Fabric Works

Data Fabric works by bringing together different technologies, tools, and procedures to improve and streamline data management.

2.2.1. The Metadata and Semantic Layer

This layer is very important for Data Fabric since it manages metadata and helps with semantic understanding.

- Metadata Management: Keeps an eye on the quality, provenance, and connections of data to make sure everything is clear and consistent.
- Semantic Enrichment: Adds context to raw data so that you may draw deeper and more important conclusions.

2.2.2. Layer for data integration

This layer combines data from several sources into one system.

- ETL and ELT Steps: Data Fabric makes it easier to use Extract, Transform, Load (ETL) and Extract, Load, Transform (ELT) methods to combine structured, semi-structured, and unstructured data.
- Real-Time Data Streams: It combines streaming data from IoT devices, social media sites, and transaction systems so that you may analyze it right now.

2.2.3. Coordinating and automating data

Data Fabric makes it easier for data to travel around and be processed in the firm.

- Orchestration of Workflows: automates data operations, making sure that data is sent quickly and accurately.
- Integration of Machine Learning (ML): Uses ML techniques to make data better and speed up processing.

2.3. Benefits of Data Fabric for Businesses

Organizations may get a lot of operational and strategic advantages from using Data Fabric.

2.3.1. Speeding up decision-making based on data

Data Fabric may help organizations make decisions faster and with more information.

- Real-Time Insights: Makes real-time analytics possible by combining data streams with transactional information.
- Advanced Analytics: Makes it possible to use advanced analytics, such as predictive and prescriptive models.

2.3.2. Breaking down Data Silos

Data Fabric gets rid of the problems that data silos cause.

- Comprehensive Data Perspective: Gives you a single, unified view of all your company's data.
- Better teamwork: It encourages teams and departments to share data, which leads to more collaboration.

2.4. Problems and Things to Think About

Even though it has advantages, putting Data Fabric into action takes careful planning and execution.

- How hard it is to put into action: Putting together a wide range of different tools and technologies might be quite hard.
- What you need to qualify: To create, carry out, and maintain the architecture, organizations require skilled professionals.
- Financial Consequences: The long-term benefits outweigh the short-term costs, although the initial costs might be high.

3. Understanding Data Mesh

Data Mesh is the latest way of building things that aims to solve these problems that come up when big businesses have to deal with huge datasets. Data Mesh is different from traditional monolithic models like centralized data lakes or rigorously controlled data warehouses in that it focuses on decentralization, domain-oriented architecture & scalability to give teams more authority and make data more accessible to everyone.

3.1. What is a Data Mesh?

Data Mesh is a framework that was designed to help with the growing complexity of huge datasets. It changes how firms organize, control & utilize their information.

3.1.1. What it is and its main ideas

Data Mesh is a way of organizing information that doesn't rely on a central server and treats data as a product. It is based on four main ideas:

- Domain-Oriented Data Ownership means that domain teams that know the data's context and purpose are now in charge of & responsible for the datasets.
- Data as a Product: Data is considered as a separate product with clear ownership, quality standards & service-level agreements.
- Self-Service Data Infrastructure: Staff may maintain and consume their data products on a standardized, self-service platform without having to go via central IT staff.

A federated model makes sure that standards, security & more compliance are the same all around the globe, but it also lets domains be more flexible.

3.1.2. Benefits of Using Data Mesh

A Data Mesh technique may help fix common problems with these traditional data management systems:

- Scalability: Decentralization helps avoid bottlenecks and makes it easier to grow without putting too much stress on these central teams.
- Improved Data Integrity: Domain owners, who know the data best, are responsible for keeping it more accurate.
- Faster Insights: Decentralized access lets teams receive insights faster by relying less on centralized processes.

3.2. Ownership of Data in a Specific Domain

The idea of domain-oriented data ownership is a key section of Data Mesh.

3.2.1. A summary of Domain-Driven Design in Data Management

Data Mesh uses domain-driven design as a way to build software and structure data. Each business area, such as sales, marketing, or finance, is responsible for its own information. This ownership makes sure that the information is more accurate, up-to-date, and useful.

3.2.2. Problems with standardizing domain-centric ownership Concerns

Domains may make data products on their own, which might lead to these differences.

- Skill Deficiencies: Some domain teams may not have the skills they need to manage & maintain high-quality data outputs.
- Governance Complexity: It takes a lot of careful monitoring to find the right balance between domain-specific flexibility & corporate compliance standards.

3.2.3. Advantages of being responsible for domain ownership

When domains control their information, it makes it clear who is responsible for keeping information up to date & of good quality.

- Understanding the Context: Domain teams know how to handle their information well, which leads to better analytics and insights.
- Reduced Central Bottlenecks: Centralized teams no longer need to manage every dataset, which frees up resources for other important tasks.

3.3. Data as a Product

Thinking of data as a product is a big transformation that lies at the heart of the Data Mesh concept.

3.3.1. What Does "Data as a Product" Mean?

Data as a product means using principles from product management on these datasets. Every dataset is seen as a deliverable, which includes:

- A Clear Goal: The dataset has certain uses.
- Identified Consumers: Knowing who will utilize the information and what they need from it.
- Service Level Agreements and Metrics: Checking the dataset's quality, usability, and performance.

3.3.2. Parts of a Data Product Discoverability

Customers in the business must be able to easily find data products.

- Usability: They need to be well-documented, with these clear instructions on how to utilize the data correctly.
- Interoperability: Making sure that datasets can easily work with many other systems and data products.

3.4. Data Infrastructure for Self-Service

For Data Mesh to work, teams need to be able to use self-service platforms that let them manage and use data without having to rely on their IT specialists all the time.

3.4.1. Benefits of Self-Service Platforms

- Empowered Teams: Teams may focus on their main objectives without having to depend on central IT to handle these data requests.
- Faster Delivery: Self-service cuts down on delays, making it easier to finish data-driven projects more quickly.
- Scalability: An automated infrastructure may grow as the amount of information it needs to handle grows.

3.4.2. Parts of Self-Service Infrastructure Data Access Tools

APIs and other tools that make it easy and secure to get their information.

- Pipeline Automation: Automatically run ETL/ELT processes to make data integration & transformation better.
- Data Governance Frameworks: These include security and compliance features that help companies meet their needs.

4. Synergies between Data Fabric & Data Mesh

Combining the ideas of Data Fabric & Data Mesh changes the way that huge amounts of information are managed in these organizations. Each technique deals with different problems in these modern data ecosystems, but when they are combined, they provide the latest framework for scalable, efficient, and open data management. This part looks at how Data Fabric and Data Mesh work together and how they can help organizations reach their goals.

4.1. A summary of Data Fabric and Data Mesh

4.1.1. Data Fabric: A Unified Data Architecture

Data Fabric focuses on creating a unified data architecture by bringing together different data sources. It uses metadata-driven design, advanced automation & smart orchestration to make sure that the information can be easily transferred and accessed in all these situations. This strategy makes it easier to combine information and lets businesses keep their data governance and security consistent.

4.1.2. Data Mesh: A Framework for Decentralized Data

Data Mesh gives domain-specific teams different responsibilities for owning & managing data. Each team is in charge of its own data as a product, which makes it easier to scale, be independent & be flexible. Data Mesh puts interoperability and shared standards first, which encourages everybody in an organization to work together.

4.2. Main Synergies Data Fabric and Data Mesh

Data Fabric and Data Mesh both have benefits that work together to make each other very better. Putting the two together may provide a data management framework that is strong & also adaptable.

4.2.1. Access to integrated data with shared ownership

Data Fabric gives everyone access to the same information and makes sure that everyone follows the same rules. Data Mesh, on the other hand, gives particular domains control of the data. They strike a balance between control & flexibility, making it easy to get to data and letting teams manage their own data products. A Data Fabric may include a complete global metadata library that all teams may use, but the Data Mesh gives domain-specific teams the job of keeping that information up to date & organizing it.

4.2.2. Bringing together old systems in a way that makes sense

Many companies still rely on their previous systems that are hard to modernize. Data Fabric is the structure that connects various systems, and Data Mesh lets domains adopt the latest approaches at their own pace, which allows for gradual transformation. They provide a mixed strategy that allows old and the latest technologies to work together without getting in the way of progress.

4.2.3. Better Data Governance and Compliance

Data governance is an important part of managing company information. Data Fabric has rules about data quality and compliance that are centralized. These rules may be changed to fit the decentralized frameworks of a Data Mesh. Data Fabric solutions may help teams automate compliance checks while still letting them control their resources at the local level. This partnership makes sure that companies follow the rules while yet allowing for innovation & freedom.

4.3. Benefits of combining Data Fabric with Data Mesh

Combining these two ideas gives businesses a lot of benefits.

4.3.1. Ability to Scale for Large Datasets

Organizations may achieve unmatched scalability by combining Data Fabric's ability to handle a wide range of information with Data Mesh's decentralized governance. Each domain may focus on its own datasets, but the overarching Data Fabric makes sure that connections across domains work smoothly. This tiered strategy makes better use of resources and improves their performance.

4.3.2. Speeding up Innovation

By breaking down data silos & making it easier for people to work together, combining Data Fabric with Data Mesh boosts innovation. Teams may look into the latest data-driven solutions without having to worry about many problems with access or compatibility. Data Fabric's global architecture makes sure that data flows smoothly, while Data Mesh's independence promotes the latest ideas to come up in specific areas.

4.3.3. Better Decision-Making

Data Mesh encourages a culture of ownership & accountability, which makes sure that data outputs are correct & also useful. Organizations may speed up and improve their decision-making processes when they use Data Fabric's advanced analytics & actual time integration together. Domain-specific insights and access to all corporate information may help marketing and sales teams improve their strategies.

4.4. Problems and best ways to combine Data Fabric with Data Mesh

There are a lot of good things that may come from combining Data Fabric with Data Mesh, but there are also some problems that come up. Organizations may get the most out of this integrated approach by using these best practices to deal with these problems.

4.4.1. Making sure that centralized and decentralized models work together

One of the main problems is how to make centralized governance (Data Fabric) & decentralized ownership (Data Mesh) work together. Companies need to set clear rules and standards for how data may be accessed, managed & kept safe. To keep everyone on the same page, central teams & domain teams need to talk to each other often.

4.4.2. Reducing Overhead and Redundancy

Because Data Mesh is decentralized, there may be instances when many other teams work on comparable data products, which might lead to duplicated work. To stop this from happening, companies may utilize Data Fabric's metadata management tools to find & get rid of duplicates. Making a complete database of reusable data assets could help cut down on these duplicates.

4.4.3. Building the Right Skills

To make this hybrid approach work well, teams need to have a range of skills, such as being able to work with both centralized structures & domain-specific data methods. To fix this lack of skills, companies need to put money into training & the development. Also, creating a culture of working together and learning from one other will make integration go more smoothly.

5. Implementing Data Fabric & Data Mesh

Organizations need to use the right data management tools since they have to deal with large amounts of data. Data Fabric and Data Mesh are new ways of thinking that make data more accessible, flexible, and scalable. Even though both methods are different, they both try to break down barriers and help businesses get value from their data. This section talks about the most important things to think about, ideas, and best practices for putting these designs into action.

5.1. Understanding Data Fabric

Data Fabric is a way to manage company information from a single location that focuses on making it easy to access, integrate & automate information from various sources. It gives you a complete view of your information & makes it easy to move and handle it.

5.1.1. Basic Principles of Data Fabric Consolidated Data Access

Data Fabric combines these different data sources, no matter where they are located, whether on-premises or in the cloud & provides a single interface for accessing them.

- Automation and Orchestration: It uses AI and ML to automate the processes of integrating, transforming & governing their information.
- Scalability: Data Fabric is designed to handle growing datasets, and it ensures scalability in terms of the amount, kind & speed of data.

5.1.2. Important Parts of the Data Fabric Data Integration Layer

Combines and integrates data from these multiple sources to make sure it is too consistent & accurate.

- Metadata Management: Keeps an eye on metadata to give it context, which makes it easier to find & trace the history of information.
- Governance Framework: Sets rules and standards to make sure everyone follows them, stays safe & gets good quality work.

5.2. Understanding Data Mesh

Data Mesh makes data management less centralized by treating information as a product and letting domain teams take charge of their own information. It emphasizes distributed architecture and ownership of data that is unique to a domain.

5.2.1. Basic Rules for Data Mesh Domain-Centric Stewardship

Each domain team is responsible for managing and providing its data as a product.

- Interoperability Standards make it easier to share data across domains by using clear APIs & also data contracts.
- Decentralized Governance: Balances freedom with these rules to keep your data quality & compliance high.

5.2.2. Benefits of Data Mesh Scalability

Data Mesh responds to the growth of a company by spreading out these responsibilities.

- Faster Insights: Domain teams may quickly make changes, which cuts down on the time it takes to get these insights.
- Improved Collaboration: Encourages data sharing & collaboration amongst these different fields.

5.2.3. Important Parts of Data Mesh

- Data-as-a-Product: People perceive information as a product that has owners, consumers, and a way to manage its lifetime.
- Self-Service Infrastructure: Gives teams the ability to build & manage their own data pipelines with less help from centralized IT.

Federated Governance sets global standards while yet letting domains make changes to meet their own requirements.

5.3. A comparison between Data Fabric and Data Mesh

Both approaches deal with problems related to managing data, but they do it in very different ways. The choice between them depends on the company's structure, culture & special needs.

5.3.1. Centralization vs. Decentralization

- Data Fabric: Supports centralization to make sure that things stay the same & are watched after.
- Data Mesh: Supports decentralization to give domain teams more control.

5.3.2. Situations for Use

- Data Fabric: Best for businesses who need to connect a lot of these different systems in a complicated way.
- Data Mesh: Good for companies with domain-focused teams that need flexible data governance.

5.3.3. Automation vs. Autonomy

- Data Fabric: Needs AI-driven automation to connect & manage their information.
- Data Mesh: Supports team independence while following universal rules.

5.4. Best Ways to Put the Plan into Action

To do Data Fabric or Data Mesh well, you need to prepare carefully, get everyone on board, and follow best practices.

5.4.1. Putting Data Fabric into action

Give integration tools the resources they need: Use advanced technology to easily connect diverse systems.

- Focus on Metadata Management: Make a plan for your metadata to make it easier to find & keep your data safe.
- Use monitoring technology to keep an eye on these data pipelines & make sure everything runs well.

5.4.2. Current Problems and Ways to Fix Them

- Cultural Resistance: To deal with these resistance, tell stakeholders about the benefits of the chosen strategy.
- The complexity of governance: To make sure everyone follows the rules, you need to find a balance between being flexible & being the same.
- Lack of tools: Put money into these modern tools and platforms to improve their architectural support.

5.4.3. Putting Data Mesh into Action

- Set Clear Domain Boundaries: Make it clear who owns what & what each domain team is responsible for.
- Set up a self-service infrastructure: Provide teams the tools & frameworks they need to be able to handle their own information.
- Standardize APIs and Data Contracts: Make sure that everyone shares & uses information in the same way.

6. Possible Changes in How Data Is Handled

The ideas of data fabric & data mesh have given businesses the latest ways to work with huge amounts of information. These frameworks try to make scalability, decentralization, and actual time analytics better while making traditional data management systems less complicated & less efficient. We look at how data management will change in the future from various points of view.

6.1. Decentralization of Data Ownership

Decentralizing data ownership is a big change in how data is managed. Centralized data solutions that are standard frequently cause bottlenecks, make it harder to hold people accountable & make it harder to get to the data quickly.

6.1.1. Framework for Autonomous Services

Decentralization has led directly to the rise of self-service technologies and infrastructure. By giving teams the tools they need to organize, process, and analyze data, organizations can make it easier for everyone to access data. These technologies make people less dependent on IT specialists & encourage a culture of making these decisions based on facts.

6.1.2. Breaking Down Silos

Data mesh supports domain-oriented ownership, which means that each business unit or domain is responsible for its own data as a product. This strategy makes sure that data producers are closer to the situation, which makes the data more accurate & also useful. When you get rid of silos, teams may work on their own without having to rely on their centralized data teams for information.

6.2. The Data-as-a-Product Model

In the future of data management, thinking of data as a product will be necessary to make sure it is high quality, usable, and reliable.

6.2.1. Explaining Clear Ownership

In a data fabric or data mesh, each dataset is like a product, and the person in charge of it is responsible for keeping it up to date, governing it, and making sure it is usable. This change makes it less likely that people will be confused about who is responsible in traditional data systems.

6.2.2. Ways to watch and provide feedback

To keep data products relevant and accurate, they will need to be watched and given feedback on a regular basis. Organizations will build up ways to get feedback from users on datasets, which will allow them to make small improvements that meet business needs.

6.2.3. Bringing Governance into the Product

Governance will move from a centralized role to a part of everyday life. Companies may keep following their policies without slowing down operations by adding automated compliance checks, metadata management & lineage tracking to the data product lifecycle.

6.3. Processing and analyzing data in real time

To be competitive, businesses need to be able to handle & analyze their information in actual time. The data fabric design does a great job of bringing together actual time data from many other sources.

6.3.1. Architectures Based on Events

Event-driven architectures will provide you ways to get data in actual time. Companies can quickly respond to important events, such problems with transactions or breaks in the supply chain, by adopting these technologies like Apache Kafka & streaming data pipelines.

6.3.2. Analysis Improved by AI

ML and AI will help us make sense of actual time information. These models can find patterns, predict trends & make these decisions automatically, which lets businesses respond more quickly to changes in the market.

6.3.3. Mixed Data Environments

Businesses rely increasingly on their hybrid data infrastructures that include cloud and on-premises solutions. Data fabric makes it easy to work together in these different situations, and it lets you analyze data in actual time no matter where it is.

6.4. Using automation and intelligence to manage data

Automation and intelligence are changing how we handle, store, and analyze their information. They are making it less necessary for people to be involved and making it more accurate & efficient.

6.4.1. Automation Based on Metadata

Automated data pipelines that are based on complete metadata are an important part of the data fabric's technique. Metadata gives data context, making it possible to route, classify, and integrate it intelligently without needing people to do so.

6.4.2. Putting Knowledge Graphs Together

Knowledge graphs are becoming more important for managing data in these organizations. These graphs provide connections and context to data, making it easier to do sophisticated queries & make better decisions in a number of fields.

6.4.3. Data Governance That Is Proactive

Data governance is moving forward to include these predictive features. AI-powered tools can find problems with compliance, find data usage that isn't normal & automatically enforce rules. This proactive method lowers the risks that come with data breaches or breaking the law.

7. Conclusion

Companies are increasingly worried about how to handle huge datasets. Technologies like Data Fabric and Data Mesh are changing the way businesses approach this issue. Data Fabric is a unified system that brings together & automates data from a variety of these sources, making it easy to access & manage. This connection makes it simpler to deal with difficult data setups & makes sure that things are always the same, which makes it easier to acquire these insights. Data Mesh, on the other hand, emphasizes decentralization by letting teams handle their own information & maintain their own datasets. These models combined provide a whole way to handle firm information that combines the advantages of automation & integration with those of decentralization & the democratization. These latest frameworks may help organizations become more flexible & also scalable, which will help them make better choices & speed up innovation. These revolutions, on the other hand, demand more than simply changes to technology. To do things well, the culture has to change such that everyone is responsible for the data, there are strong governance systems in place, and people are committed to learning and adapting all the time. Companies who use both Data Fabric's technology benefits and Data Mesh's organizational independence will be able to perform well in the era of big data, which will help them stay competitive and strong.

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