The Maturity Measurement of Big Data Adoption in Manufacturing Companies Using the TDWI Maturity Model

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Abstract

Background: Big data technology has been used in several sectors in Indonesia. Adoption of big technology provides great potential for research, especially achievement in the implementation of big data in manufacturing companies. The Data Warehousing Institute (TDWI) Maturity Model is a tool that can be used to measure the state of "As-is" implementation of big data using 5 main dimensions. Maturity level shows the level of organizational ability to adjust big data technology currently.

Objective: This study aims to measure the level of maturity in the implementation of big data technology in manufacturing companies PT. XYZ. This measurement is considered very important because it can know the process of managing data that is structured and has a high volume of data and provides more transparent reporting. This can help the company in making decisions that provide good information, so the company can increase the trust of stakeholders.

Methods: This study uses qualitative methods to analyze research data using TWDI Maturity Model tools. Interview technique is used to retrieve respondent data where interview preparation guidelines are made by paying attention to 5 dimensions and 50 indicators in TDWI.

Results: The research showed that the implementation of big data technology in the company as a whole has reached the level of corporate adoption. Infrastructure, data management, and analytics dimensions have reached the corporate adoption level while the organizational and governance dimensions are still at an early adoption level.

Conclusion: To measure the maturity level of adoption of big data technology in manufacturing companies can use qualitative methods with TDWI Maturity model tools, interview guides for data retrieval by considering the 5 dimensions and 50 indicators that exist in TDWI.

I. INTRODUCTION

Through information technology, data bytes are created every day from various sources, such as from science experiments, social media, social network activities, video controls, smart grids, telecommunications data, and surveillance systems, sensor systems, and daily business and financial transactions [1]. This sea of data leads to one Big Data terminology. Data has an important role in strategic decision making. Therefore, those who are able to process and use data that are available in large volumes, variations, speeds and high data rates, can take large profits [2]. However, the application of Big Data analytics is still not very popular in Indonesia [3]. So far, the three business sectors of Big Data users in Indonesia are telecommunications, banking, and government sector [4] [5].

Big Data technology can actually be used by many parties, both large companies, small and medium businesses, and government. Even though using Big Data is complicated and expensive, even small-capital SMEs can use it to

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find out their business goals so as to facilitate the process of collecting the required data, to get greater benefits from the investment incurred [6].

Some of the Big Data Benefits that have been received specifically for the business world are released to find out the general public response to the merchandise issued through sentiment analysis on social media; helping companies retrieve data accurately and accurately; help improve the company's image in the eyes of customers; for business planning with companies, such as telecommunications and banking companies; and knowing market trends and consumer desires [7].

Besides being useful for business analysis, Big data technology may be wide employed in government and corporations [8]. Some opportunities to use big data within the public sector embrace to urge feedback and public response from the government service information system as well as from social media, as a basis for formulating policies and rising public services; Finding solutions to the questions in the data, for example by analyzing information on prices and soil fertility, the government can request or call on the types of plants planted by farmers during a sure space and time; and assist in the management and supervision of state finances [9].

Uploading the big benefits that Big Data technology trends can offer, specifically in the public sector, it is interesting to allocate where Big Data technology has been used in various government agencies in Indonesia, and encourage whatever arises in its application [10]. The application of Big Data technology in institutions can be seen from the functions that are already available in IT infrastructure, so that it can be used to connect with mobile, social, and Big Data-Analytic applications.

The term Big Data began to emerge after 2005 was introduced by O'Reilly Media. But actually, the use of data and the need to understand the data actually has existed since time immemorial [11]. Many parties try to define Big Data [12]. It can be concluded that Big Data refers to 3V: volume, variety, velocity, and some add other V elements such as veracity and value. Volume relates to the scale of a data storage medium that's terribly large or even unlimited to petabytes or zettabytes; selection involving the sort or kind of data which will be processed ranging from structured data to unstructured data; whereas velocity is expounded to the speed of process data generated from various sources, starting from batch data to real-time, whereas the characteristics of veracity and value are involving the uncertainty of the data and therefore the value of the advantages of the information generated.

Several studies have been conducted to measure the status of Big Data implementation in several organizations. One of them is the 'Big Data Survey' research, conducted by Capgemini Consulting in 2014 to 226 leaders of global companies/organizations in Europe, North America, and Asia-Pacific. The results of the study found that the most (35%) of the organizations studied were at the partial production level, where predictive analytics technology had been integrated into some business processes. While others are in the concept planning level (29%), not yet implemented (24%), and only 13% have reached the level of proper utilization [13].

The potential use of Big Data for government and corporate services in Indonesia has been previously reviewed [14]. The article said that the government as a public service provider has the opportunity to use Big Data in several e-Government service processes. Integrating data and services is one way to take advantage of Big Data. Many sectors that can be synergized include transportation, agriculture, employment, plantations, marine and many more. The study also provides benchmarking for governments that have used Big Data in several public services, such as Japan, the United Kingdom, Taiwan, Thailand, and Korea, but unfortunately do not yet describe the use of Big Data in government in Indonesia.

Maturity of the application of Big Data is intended to demonstrate the evolutionary process carried out by an organization in integrating, managing, and utilizing all relevant data sources both internal and external. This includes creating innovative ecosystems, providing useful business value, and enabling transformations that have an impact. In other words, the maturity of implementing Big data isn't solely regarding having some technology to handle high-volume data or simply about exploitation social media to analyze popular opinion, but a process that involves building ecosystems that include technology, data management, analysis, regulation, and components organization [15]. TDWI version of the big data maturity model consists of five levels: nascent, pre-adoption, early adoption, corporate adoption, and mature/visionary.

Discussion about the challenges faced in implementing Big Data and its relation to development policy in Indonesia is still small [16]. In fact, in the future public policy will be shaped by Big Data and its application in various aspects of public life such as in the education, health and public services sectors, companies, and others.

Based on the description above, the purpose of this study is to measure the maturity level of implementation of big data in manufacturing companies PT. XYZ to get a more structured process of managing high volumes of data to provide better reporting transparency, make well-informed decisions and instill better trust from stakeholders. This analysis was conducted in PT. XYZ companies, because the corporate has adopted big data for five years, the turnover obtained per month is quite four trillion. It is expected that the results of research can provide information

and inspiration so that applying Big Data technology in Indonesia can be more extensive, especially in government agencies and companies [17].

II. METHODS

This research has been conducted in four steps, summarized as follows:

A. *Defining variables and indicators*

This analysis was conducted on PT. XYZ companies. There are five dimensions used to measure maturity level implementation of big data, namely organization, infrastructure, data management, analytics, and governance. Each dimension was divided into The Data Warehousing Institute (TDWI) version of the big data maturity model consists of five indicator level: nascent, pre-adoption, early adoption, corporate adoption, and mature/visionary [18]. The summary dimension and the indicator at each TDWI big data maturity model is presented in Table 1.

B. *Defining respondent in-depth interview*

This research was conducted in PT. XYZ companies, the company has adopted big data for 5 years, the turnover obtained per month is more than 4 trillion. The total number of employees is more than 5000 employees, employees in the ICT department around 500 employees. This study uses a qualitative approach, with data collection techniques through in-depth interviews with several people in charge or information technology managers in the ICT department of PT. XYZ, to get a general image of the utilization of Big Data technology in these institutions, as well as the challenges faced in its application. All respondents came from the Department of ICT with details of respondents as shown in Fig. 1 and Fig. 2. Criteria for selecting respondents based on position and work period
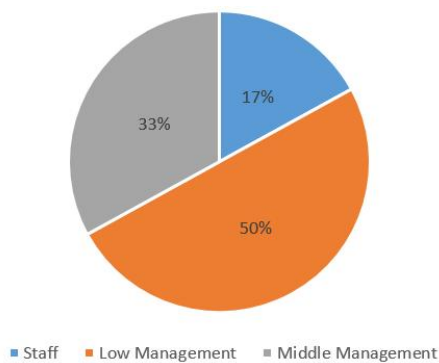

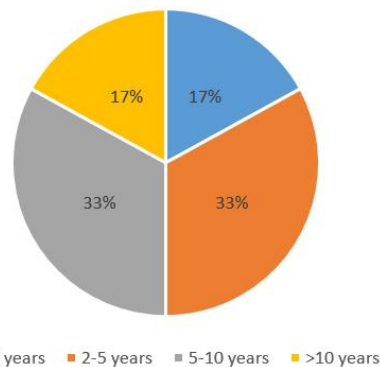Fig. 1 Profile of respondents based on position

Fig. 2 Profile of respondents based on working period

Furthermore, the data were analyzed using TDWI (The Data Warehousing Institute) Big Data Maturity Model [19], to evaluate the maturity of the application of Big Data technology. The TDWI maturity model was chosen compared to other Big Data maturity scales, such as the Gartner model or Capgemini's Predictive Analytics Maturity Framework Assessment (PAMFA), with consideration that it is easier to understand and accommodate Big Data implementation from the nascent to the mature/visionary level [20].

TABLE 1
A SUMMARY OF THE INDICATORS AT EACH TDWI BIG DATA MATURITY MODEL

Dimension/ Level	Nascent	Pre-adoption	Early-adoption	Corporate adoption	Mature/visionary
Organization	Has not nonetheless began to explore advanced analytics or begun its big data journey.	The mindset is generally around experimentation. The team is making an attempt to see the highest business issues to resolve.	Gets excited regarding the prospects of big data, a lot of folks begin to come back on board.	Realize that analytics could be a competitive person, Innovation in knowledge and data analysis could be a core worth, and an analytics culture prevails.	Executives read big data analytics as important and commonplace for the way to try and do business, unceasingly crucial new ways that to use and make value from analytics, collaboration becomes culture.
Infrastructure	No specific infrastructure to support critical big data components.	May be trying out Hadoop or big data technologies as part of the experimentation.	There may be various kinds of big data technology in place, typically a tier 2 production-class cluster that is installed and maintained in the company's data center or even in the cloud.	Typically a tier 1 production- class cluster. The information architecture is unified that underpins the analytics, can perform multiple workloads on a cluster, comply with backup and recovery or disaster recovery procedures.	Deployed coherentanalytics infrastructure, able to integrate new sources of data for analytics, there is security, disaster recovery, backup and recovery, performance management, and proactive infrastructure monitoring.
Data management	Having some sort of data warehouse. But its data strategy and data life cycle management strategy are not strong.	May have started to identify and collect some big data sources.	Have data collected as files of different formats, potentially with division or enterprise standards for naming and storage management.	Make use many forms of data, well managed data sharing, has metadata and defined end state data architecture, defined data life cycle management and data auditability.	Can manage complexity, data is shared across the organization.
Analytics	Typically, if the organization has utilizing advanced analytics such as predictive analytics, it is working with structured data only.	Has explored some kind of advanced analytics.	May be utilizing descriptive or even predictive analytics, depend on the problem to solve.	New data coming can be analyzed quickly and made part of the logical infrastructure, analytics supports the organization, has center of excellence (COE) that serves different parts of the organization.	Makes use of all kinds of data, including real-time data, and uses this as part of its decision making and incorporates into business processes.
Governance	Governance strategy is more IT centric than business-and-IT centric.	Have a steering committee overseeing the program from a governance perspective.	Have corporate sponsorship and infrastructure, but yet settle governance team.	Have program governance with PMO and steering committee, executed program as budgeted and planned enterprise initiative.	The program is treated as mission critical and given the right amount of staffing and skills.

C. *Analyzed levels of maturity on TDWI big data maturity model*

This study uses a qualitative approach, with data collection techniques through in-depth interviews with several Maturity of the application of Big Data is intended to demonstrate the evolutionary process carried out by an organization in integrating, managing, and utilizing all relevant data sources both internal and external. This includes creating innovative ecosystems, providing useful business value, and enabling transformations that have an impact. In other words, the maturity of implementing Big Data isn't around having some technology to handle high-volume data or just about using social media to analyze public opinion, but a process that involves building ecosystems that has technology, data management, analysis, regulation, and elements organization [21]. TDWI version of the Big Data maturity model consists of five levels: nascent, pre-adoption, early adoption, corporate adoption, and mature/visionary as presented in Fig.3, and look at five dimensions, namely: Organization, Infrastructure, data Management, Analytic, and Governance.

Fig. 3 Level of maturity within the TDWI Big Data Maturity Model

Explanation for every level: Level 1: Nascent. At this level, it appears that the leadership of the organization does not care and does not support the adoption of big data technology, the organization also has a low awareness in the adoption of big data technology. At this level, the organization already has a data warehouse but doesn't or doesn't know how to analyze the big data, so the big data cannot present information that helps the organization in making decisions or streamlining the organization's business processes. Usually, at this level, the governance strategy tends to be IT-centric not yet on business and IT-centric.

Level 2: Pre-adoption, the organization begins to conduct an analysis related to big data technology; the staff in the organization begins to seek knowledge about big data technology by exploring topics about big data adoption. Organizations usually start looking for consultants to become partners in the development of big data implementation. At this level also the organization may have been investing in using new technologies such as Enterprise Resource Planning (ERP), to support the application of big data analysis. The organization also knows that it will implement big data in running its business even though it is only within the scope of the department. At this level organizations usually have a team tasked with mapping the organization's main business processes and trying to identify those processes as to what big data technology would be suitable for implementation.

Level 3: Early-adoption, At this level, the organization already has a concept to implement big data that is ready to be executed. The leaders of the organization began to be interested and excited about implementing big data because at this level it was clear that there was a concept that was mature in analyzing big data. Usually, at this level, there is a team formed to plan and structure the big data implications. This level is the most difficult and time-consuming, because organizations must be thinking and considering switching to the adoption of big data in conducting data analysis.

Level 4: Corporate adoption, the organization is concerned with big data technology, because it is aware that with the existence of big data technology, organizations can be competitive. It has been seen in making decisions on organizations already utilizing big data analysis. Organizations have begun to cultivate innovation in management analysis using big data technology for core processes. At this level, end-users are already involved in the use of big data technology, and users also get insights related to big data analysis. At this level, the return on investment (ROI) in the organization is available by using big data analysis. Organizational strategy at this level is usually top-down and bottom-up by utilizing data infrastructure in support of organizational strategy.

Level 5: Mature/visionary, the organization has made full use of big data technology in the business processes that have been carried out, and is supported by infrastructure that is highly adapted to the organization's program and governance. At this level shows that the leaders in the organization are very concerned with the existence of big data technology, they see this big data technology as a critical factor in doing business. For the implementation or maintenance of big data is always planned and budgeted every year. The organization considers data analysis and an innovative mindset to be a competitive weapon. At this level, it is seen that organizations always come up with new ways to continuously produce good and correct data analysis. Team collaboration is a culture that is usually reflected at this level. There are only a few companies that are already at this level.

D. *Analyzed the TDWI Big Data Maturity Assessment Criteria*

As for the conditions for the five dimensions at each level of Big Data maturity as described in Table 1 above, where to assess the maturity of Big Data in an organization, TDWI has developed a measurement instrument based on factors as shown in Fig. 4. There are about 50 questions used to assess the maturity level of big data, each dimension has 10 questions. Questions are also adjusted to the state of the field [12], each dimension has a maximum score of 50 points. Evaluation of each dimension is carried out separately and each score is given. The output of this study is the overall score of all dimensions by taking the average of all dimensions scores obtained, as well as providing recommendations, suggestions, and best practices for reaching the next level of maturity.
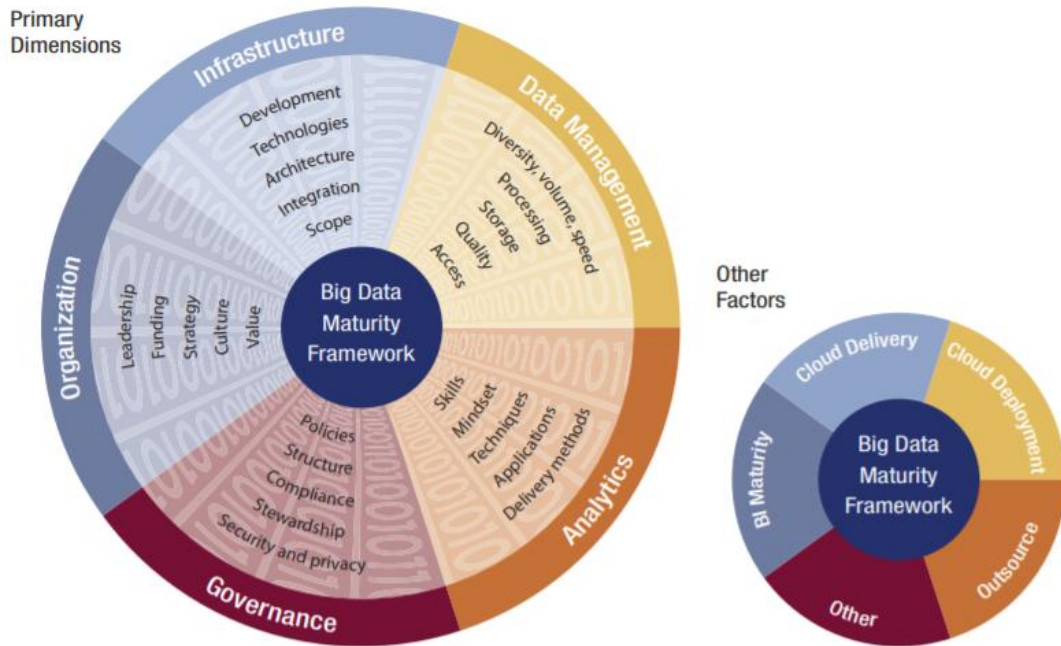
Fig. 4 Scores are supported 5 primary dimensions of big data maturity, and many alternative factors. (Source: TDWI Maturity Model)

After completing data retrieval to the respondent, it will be mapped on the assessment score that refers to each dimension in the TDWI Maturity Model. The score table for each dimension is shown in table 2.

TABLE 2
THE SCORES FOR EACH DIMENSION

Score Per Dimension	Level
<15	Nascent
16-25	Pre-Adoption
26-35	Early Adoption
36-45	Corporate Adoption
46-49	Mature
50	Visionary

This assessment is obtained from the average score for primary dimension of one respondents as shown in Table 2, of course, through interviews and analyzing the results of the interview into a value conversion. When the assessment is complete, Table 3 shows the score.

TABLE 3
TOTAL SCORE ASSESSMENT

Dimension	Score	Level
Organization	17	Pre-Adoption
Infrastructure	37	Corporate Adoption
Data Management	27	Early Adoption
Analytic	20	Pre-Adoption
Governance	10	Nascent

III. RESULTS

The measurement was done by using TDWI Big Data Maturity Model. Based on the results of data collection in the field, it will be explained and analyzed the implementation of Big Data technology in PT. XYZ Company that has initiated and utilized Big Data in its business processes. TDWI Big Data Maturity Model analysis framework is used to determine the level of maturity of the application of Big Data technology in the company. Maturity status can be characterized by indicators on five dimensions including: organization, infrastructure, data management, analytics, and governance, so that it can be concluded whether the application of Big Data technology in the company is in the nascent, pre-adoption, early adoption level, corporate adoption, or mature/visionary.

TABLE 4
TOTAL SCORE ASSESSMENT IN THE PT. XYZ COMPANIES

Dimension	Score	Level
Organization	33	Early Adoption
Infrastructure	38	Corporate Adoption
Data Management	36	Corporate Adoption
Analytic	36	Corporate Adoption
Governance	34	Early Adoption

TABLE 5
IDENTIFICATION OF INDICATORS SUPPORTING THE IMPLEMENTATION OF BIG DATA ON RESEARCH OBJECT

Dimension	Indicator	PT. XYZ Companies
Organization	Leadership	v
	Funding	v
	Strategy	v
	Culture	
	Value	v
Infrastructure	Development	v
	Technology	v
	Architecture	v
	Integration	v
	Scope	v
Data Management	Diversity volume speed	v
	Processing	v
	Storage	v
	Quality	v
	Access	v
Analytics	Delivery methods	v
	Applications	v
	Techniques	v
	Mindset	v
	Skill	v
Governance	Security and privacy	
	Stewardship	
	Compliance	v
	Structure	v
	Polices	v

From the identification process carried out in Table 4 and Table 5, it can be said that the application of Big Data in PT. XYZ company at the level of corporate adoption for the dimensions of infrastructure, data management, and analytics. As for the dimensions organizational and governance, it still reaches the early adoption level.

This is characterized by the integrated Big Data supporting infrastructure, where end-users have been involved in the system and benefited. With the existing Big Data analytic system, real conditions in the field can be known so that it helps leaders make decisions and improve service quality. To be able to reach the mature/visionary category, several things that need to be improved in the PT. XYZ company analytic Big Data system are adding cloud infrastructure, improving aspects of data security, and enhancing the work culture and awareness of employees and stakeholders to utilize the Big Data technology that has been built.

IV. DISCUSSION

Many parties agree that the application of Big Data technology brings benefits to the organization's goals and performance [22] [23]. However, its implementation is not without obstacles. From interviews with PT. XYZ company information technology managers, it can be concluded that there are several challenges in the adoption of Big Data technology in Indonesian companies, namely: Data Availability, one key to doing Big Data analysis is, of course, the availability of data. Access to data, both old data and new data can be a barrier for Big Data, especially for old data that is stored in different forms and often even in physical form. Access to new data also requires more effort because of the need for permits and licenses to access non-public data legally. Especially, if there is an ego from the department as the owner of the data. This is felt by the service and information providers who implement Big Data analytics in the company, that the data collection phase is a major challenge. Actually, in the company, data for various types of needs are already available and a lot, but the sources are scattered, so it takes more effort to get integrated data corporately. So the principle of Data Sharing and even Open Data is needed.

Data Privacy, on the one hand required data disclosure, but on the other hand, privacy is a sensitive issue and is often injured through technological advancements. Privacy relates to a person's data that must be protected. The data used as big data by for instance the telecommunications and banking industries that are obtained directly from customers, several of that are personal data and are terribly liable to be victimized by alternative parties. The utilization of a person's data should be with the consent of the involved if it'll be used by other parties. Therefore, the government is currently drafting a Bill on the Protection of Personal Data and Information to protect the personal data of citizens. The use of Big Data technology is not prone to data privacy issues. Citizens' security must be considered, where criminal actions that might arise as a result of information disclosure must be anticipated, especially those that affect the stability of the country.

So far, the application of Big Data in state is obligated to adapt the laws and laws that have ruled data or info protection and restrictions on its use, together with the data and Electronic Transaction Law, the general public info Openness Act, the Banking Act, and also the Client Protection Act.

Human Resource (HR) competence, in utilizing Big Data in government, ideally, HR are needed in the field of data analysis (data scientist), have analytical skills, computer programming skills, and ability to work out new ways which will be done to gather, interpret and analyzed data. Although data scientists may not develop their analytic tools, they must be able to sort out the various tools that will be used and select and organize data to be analyzed.

Supporting Infrastructure, all Big Data analysis tools on the market can be used by companies. Companies can use Big Data tools from third parties that have been tailored to their needs, as well as build and maintain their own Big Data systems. The calculation of the cost-benefit analysis of the two choices needs to be done by the intended use. For certain cases, Big Data analysis with Natural Language Processing (NLP) is required which can process digital Indonesian conversations, which is a limitation of some open source systems.

Data related issues are a major challenge, both in terms of providing and integrating the data needed to produce a proper business analysis, as well as data security and data privacy issues [24]. In addition, it is also known that the challenges of implementing Big Data in government institutions are not much different from those implemented in other organizations such as companies [25], where the factors of human resource skills and supporting infrastructure [26] are challenges that must be considered [27]. This is related to the presence of Big Data technology which is still relatively new to be implemented in organizations. So do not be surprised if it is predicted that the scientist data becomes the most promising work in the 21st century [28].

This research is limited to manufacturing companies, certainly very different if this research is applied to other organizations, because not all organizations implement big data in their business processes. The validation of this research is only limited to the recognition of company leaders, there is no validation from experts measuring the implementation of big data.

V. CONCLUSIONS

The role of data is very important especially entering the era of data explosion or "Big Data". The availability of large-scale and inexpensive data today should encourage various parties to utilize it through the implementation of Big Data analytics. Opportunities and benefits of implementing Big Data are very potential, including in companies and government agencies. By using data, public policies can be designed and implemented more effectively and precisely to achieve the goals.

From the results of a qualitative study, it can be concluded that PT. XYZ companies can be categorized as being at the corporate adoption level. Regarding the challenges in the adoption of Big Data technology in the company, it can be concluded 4 things, including data availability, data privacy, HR competencies, and supporting infrastructure. For further research, it is expected to use quantitative and qualitative research methods simultaneously, by

developing several dimensions and indicators on TDWI Big Data Maturity Model, to provide accurate measurement results for the maturity level Implementation of Big Data for enterprises.

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