Approaches for latency optimization using fog computing in Smart Factory.

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Abstract

As Smart manufacturing increasing by laps and bond, Industrial automation gains its momentum, an increase in the number of “Smart” production machines has been never seen before. Reenergize a traditional distribution value chain, enabling mass customization and a real-time information exchange between buyers and manufacturers using IoT for drug asset management possible with the help of fog computing concept. Manufacturers are slowly beginning to transform their manufacturing facility into an integrated network of Cyber-Physical Systems, also known as "Smart Factory". Additionally, technological advances in the fields of Cloud Computing, Internet of Things, and Distributed Computers have also led to produce large amount of data. In contrast, small Manufacturing facilities often fall behind when it comes to merging downstream production facilities with Cloud due to a lack of IT infrastructure and associated costs. Besides, manufacturers are concerned about data privacy and integrity when they view Cloud Manufacturing as a means of distributing and exchanging data. In such cases Fog computing is a natural alternative of cloud computing, Fog computing characteristics, compression with cloud computing detail out clearly. For improving latency time various AI method of scheduling with their benefits compression table mentioned. Fog computing is a data platform that distributes data generated in the production environment intelligently by resources in various parts of the cloud network while promoting data privacy and ownership, using the Fog Computing paradigm.

Keywords: AI, ML, Fog Computing, Edge computing, Cloud computing, Latency, optimization.

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Introduction

Smart factory shop floors are focused on digital transformation and taking a major step in integrating their IT infrastructure, with stores, this operational shift is considered to be a change called Industrial 4.0. The term ‘Industry 4.0’ emerged during the Hannover Conference in 2011 and represents mainly the current trend of automated technology in the manufacturing industry, which includes a combination of advanced technologies such as Cloud Computing, Internet of Things (IoT) and Cyber. -Physical Systems (CPS).

Industry 4.0 builds a comprehensive network of sensors, smart devices, processes that reduce human communication and benefit productive businesses by performing complex tasks. The basic design principles of Industrial 4.0 can be managed with a combination of technologies that include cyber-physical Systems, IoT, cloud computing, Industrial Integration, Enterprise Architecture, SOA [2]. Connected production systems and data acquisition on intelligent machines including CPS will be updated the existing manufacturing shop floors into the Factories of Future.

Background of the study.

A number of devices will be connected to the Internet, from simple tools to modern production machines built with flexible production systems that are growing rapidly. This increase in the number of devices is accompanied by a large flow of data from these devices, which is very important, and if used wisely, can change the flow of current production activity. In this case, small and medium-sized producers are well equipped to use this data due to the complex software platforms and large investments associated with these sites or services. Besides, data control, data privacy and security are also a major cause of frustration among producers. In a broader sense, to make full use of this data both from a sensory network or smart devices is a solid, interconnected interface that includes sensors, RFID tags, smart devices, software applications, search engines and search engines such as practical capabilities. Well in terms of communication features and network features are required which can be achieved using the power of Fog Computing (Cloud Computing extension), Industrial Internet of Things and computer nodes equipped with storage and communication capabilities. According to us, the Fog Computing paradigm can be beneficial in solving current problems and the limit of Cloud Manufacturing by proposing a horizontal architecture to support different applications in an intelligent production environment. Increasing the level of zoning leads to increased privacy in the development of Fog Computing. Each Fog Computing platform can be unique and can be used specifically depending on the tools used, software components, security, and privacy. In summary, Fog computing enhances data privacy as the number of channels through which data travels is large and hidden from the client.

The basic idea of Fog Computing is to extract computer and data integration functions into a network of distributed computer nodes located near virtual data centers. Doing so will solve the problems of delays and problems with the current Cloud Manufacturing data bottleneck. According to us, Fog Computing is needed to refine the existing paradigm to accelerate digital transformation under the Industrial 4.0 version. Several challenges will arise when a large number of connected devices, production facilities are located in the same area as the computer infrastructure. As a result, the performance of Industrial 4.0 may be slowed down.

Real-time data from Smart Machines: The rapid development of Industrial Internet of Things and advances in modern communication agreements has stimulated the mass distribution of data from the sensory network and other smart devices. As a result, the performance of existing applications driven by cloud-based production data proves a decline. In addition, an integral part of peripheral devices or data sources in the production environment intelligent systems on chip IoT devices communicate with lightweight contracts such as MT Connect [4], ZigBee [5], and OPC / UA [6].

To create error-free, scalable, and robust middleware of production equipment, which can allow the exchange of high volume data with distributed fiduciary nodes (Fog Nodes).

To demonstrate the use and benefits of containerization approach for Fog Node deployment in a smart manufacturing environment.

Smart Industry communication protocol Framework.

Industry Protocol and Communication Framework 4.0 Principles of communication and technology are the foundation of any Industry 4.0 Architecture. In this section, we will discuss communication agreements, security agreements, large data transmission tools, and other industry standards.TCP (Transmission Control Protocol) and Web Sockets TCP or Transmission Control Protocol is very important in the IoT environment. As a connectivity-focused protocol, TCP tracking packets and transfer method is available in the event of packet loss. In addition, TCP has many functions as it can be used in conjunction with AMQP, MQTT [10], and most importantly, the REST structure [7]. Web socks are a continuation of the old client server architecture and provide duplicate TCP communication channels. In simple terms, web sockets establish continuous communication between client and server, allowing both organizations to send and receive data. Web socks are widely used to send data from server to client but do not allow low power computing devices [8].

XML / JSON

Extensible Core Language provides a standard way to encode documents that allow them to be readable and readable in person to exchange data online. In addition, XML is also used today to represent inappropriate data objects [9].

JSON or JavaScript Object Notation is used to represent data in keyword pairs and serialized data. Since data representation is irrational in the IoT environment, the two most common data formats are XML and JSON. As a result, in a broader context, these two formats form the core of the IIoT connection although JSON is considered the standard IoT format as it is simpler and compatible with REST architecture.

HTTP/REST

The Internet relies heavily on REST or Representational State Transfer architecture, which relies on HTTP. REST is a software-based architecture that provides a high level of interaction between computer systems over the cloud. These services allow clients to access text presentations through "status" functions. A non-standard protocol is not required to store information about the user status when multiple requests are handled. The connection is set up through a fog layer usually using the REST HTTP protocol, which provides additional flexibility for software developers to assist customers. The set of HTTP-approved functions are GET, PUT, POST, and DELETE.

MTConnect

MTConnect is an industry standard adopted by the industry developed to exchange data and establish connections between cyber-physical systems. Data generated by the MTConnect protocol is primarily used for machine monitoring and analysis of data generated during the manufacturing process. MTConnect is an open source protocol that provides XML-based backend format. There are two components, namely the MTConnect agent and the MTConnect adapter. Data is retrieved via the MTConnect adapter and the adapter also transmits this data to the MTConnect agent. The agent continues to store this data on a TCP server and provides a virtual REST interface, which means the data can be retrieved in response to an HTTP request, allowing the data to be used by multiple clients locally.

Publish/Subscribe Messaging System

The Publish / Subscribe messaging system is a software design in which the data sources that produce messages do not send them directly to recipients or subscribers but instead are categorized into different topics. The Publish / Register model is widely used in small service buildings, and an important feature of the Publish / Register model is that it cuts applications that improve system scaling and performance. Manufacturers do not produce consumer messages, and similarly, consumers express their intentions by subscribing to articles rather than using messages from the manufacturer directly.

Apache Kafka & Apache Zookeeper

Apache Kafka [23] is a distributed data distribution platform with integrated capabilities for data transmission, storage, and messaging system. Kafka uses message publishing / registration to transmit data through secure and secure pipelines in real time and converts data between cyber-physical systems that form the backbone of the Industrial 4.0 architecture.

Data Distribution in Manufacturing Systems

A lot of work has been published, suggesting a number of ways and means to establish links between distributed components of cyber-physical systems. The focus of these papers is on various communication systems integrated within systems to support the massive flow of data generated in a widely distributed and fragmented cyber-physical system. [12] Data management and reliable communication processes are the realities of successful structures. One of the first tasks, he proposed a control system based on architecture to control dynamic applications in a modular production environment [13]. The literature has identified important issues that occur during normal production and how they fail as the complexity of system integration grows. The authors proposed building structures using the DDS protocol, which allows industrial robots and production organizations to communicate in a flexible production environment. The same dynamic automation method was proposed by the authors in, which introduces real-time, DDS-independent platform system and case studies involving a modular correction system.

Ungurean and Gaitan negotiate data distribution cooperation [14]

SCADA program service. The structures used in the paper by the authors are based on the OPC protocol, which uses DDS middleware to distribute data and establish links to SCADA programs [15]. The essence of all the proposed structures is the various communication processes that ensure effective communication between production systems.

Cloud Manufacturing

The name Cloud Manufacturing was coined in 2011 [16], which propelled the idea to become a service-based business model that enabled manufacturers and medium-sized businesses to use their resources on a central cloud platform. The current state of production after the Industrial 4.0 fluctuation is under great pressure to significantly reduce the cost of production processes and make the process more flexible as small and medium producers have begun to take steps towards digital transformation. The new Cloud Manufacturing paradigm has transformed typical production from production-based models to service-based models using modern IT solutions such as Cloud Computing and Internet of Things [17]. This paradigm shift now allows manufacturers to use their storefronts more effectively in conjunction with smart summaries to allow data to analyze and distribute production resources. In addition, the production capacity required and customization of the product quickly requires high technology, Basically, Cloud Production is based on Architecture focused on low cost paid modeling services, reliable computer resources of manufacturers which are great. To encourage SMEs who want to join Industrial Revolution 4.0 and use the reliability model based on resources.

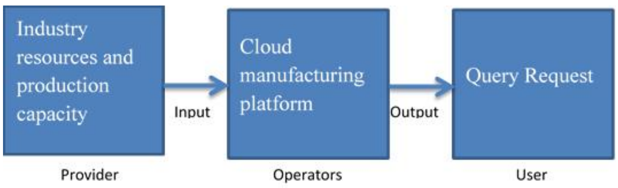

Figure 1 Operating Principle of Cloud Manufacturing

Cloud Manufacturing has been gaining momentum lately. Many small producers have moved their ERP systems to Cloud, which has attracted more organizational flexibility and significantly reduced operating costs. In addition, the migration of production services to Cloud has significantly reduced the huge investment required for IT infrastructure and computer hardware. Manufacturers appropriately use each payment model by dedicating the time and cost spent in setting up and managing IT resources [18].

Cloud Services as it grows rapidly, has helped manufacturers make key product data more accessible to interested people. To make the manufacturing business a success, Cloud Manufacturing also brought independence within the producers, and helped the producers focus more on their technical area, which contributes significantly to the efficiency of the organization. In addition, marketing time is also significantly reduced using Cloud Manufacturing as a customer service. Cloud Manufacturing is also a disadvantage when it comes to a few things. An important cause for concern is computer performance, which will be problematic as several smart machines and old legacy machines will be connected to the IT space. Loss of connection is also a matter of concern because cloud production depends on a single communication channel. The main disadvantage of Cloud Productivity is that a lot of confidential data and information about production services are immediately provided to Cloud to provide you with one point of failure. This placement is a major reduction in the confidence of small and medium producers whose data is the most valuable asset to them.

A possible solution to the problems mentioned above, which formed the basis of this thesis, is Fog Computing, which will be explained in future sections.

Limitations of Cloud based Manufacturing

Cloud Manufacturing has improved the manufacturing environment. Manufacturers can now use managed IT resources to store their production resources, ERP systems without sacrificing their time and money to maintain internal infrastructure. However, Cloud seems to have several limitations as IIoT and Cyber-Physical systems increased.

The amount of data generated by the MT Connect protocol is very large, and when the amount of equipment is measured, the current cloud computing technology will not be sufficient to control the data distribution. In addition, big data will create network connections that lead to problems of latency and application bandwidth as this will largely depend on the distance between the visible area of the production facility and the data center. The authors in [19] investigated the performance of Cloud computing against data types and found significant differences in performance with the corresponding increase in the accuracy of floating point numbers. Since data generated in intelligent production environments is extremely accurate, transferring large amounts of data can cause damage to computer performance. In addition, as the distance between the data source and the Cloud data center increases, network costs increase, which is an overhead for small and medium producers. In addition, another major cause for concern is data integrity issues that result from moderate data storage and multi-user sharing [20]. Lastly, manufacturers are often locked up with Cloud service providers, and as data volume grows, data transfer also becomes more complex and difficult. The above limitations can be addressed by "Fog Computing," which is described in the following sections.

Overview of Fog Computing

As discussed in previous sections, the concept of Cloud Production takes a back seat when it comes to feeding applications with high output and low latency. In addition, Cloud Manufacturing's compactness prevents small producers from sharing their data resources as they fear losing control of their data or fear of data fraud. A possible solution to this problem is Fog Computing, launched by Cisco [20] in 2014. Fog Computing is defined as an extension of the existing cloud computing paradigm that integrates distributed computer concepts that bring intelligence to the forefront. By introducing an intermediate layer of distributed nodes capable of computing, storage and networking between IoT enabled devices and a highly efficient cloud. It can be seen as a situation in which a large number of different devices, a wide range, are separated by a network that interacts with each other to perform maintenance and processing tasks without the effective intervention of external companies. Services are still distributed through a fiduciary node network with no conflict of interest with data sharing participants. An important feature of Fog Computing is that it frees the count to distributed nodes and thus improves the performance of sensitive latency applications [20]. Distributed native Fog Computing is of great benefit to producers as it distributes information that may be required for the use of low latency, e.g. if an employee or designer is interested in a particular client's data and is not currently in place. With the successful implementation of a large network of sensors that transmit real-time data under Industrial Internet of Things, Fog Computing helps producers store their data in reliable storage locations and at the same time use its data through. Statistics. Cloud Storage compatible with Fog Computing is one of the best solutions to ensure that IIoT applications are not compromised under heavy data. In addition, Fog computing proximity to the IoT-enabled production machine, is very capable of reducing the distribution of manufacturer data, for example by analyzing sensitive data on a fog device instead of outside the control of the manufacturer that promotes privacy. And brings more transparency when sharing a production tool [17]. The Open Fog consortium has played an important role in defining the framework for Fog computing system. Open Fog [17] white paper for architectural reference. The next section will explain the features of Fog Computing in detail.

Characteristics of Fog Computing

Basically its cloud expansion, but it's similar to things that work with IoT Data. As can be seen in the picture above, the use of fog acts as a mediator that connects to cloud and end devices, bringing storage and communication resources and processing closer to end-to-end devices respectively. Provides minimal delay and location awareness due to the localization of fog nodes. Provides flexible backup connector services, computing and communication between storage computers and standard Cloud Computing data centers. It has the following features

Lower latency-fog nodes are closer to attached devices making response time much less and processing data faster. Supports awareness of areas where fog in various locations, nodes can be installed.

Mobility- Due to the advanced state connection between fog and devices provides better mobility

Real-Time Interaction - Due to the proximity of devices and the interaction of fog nodes it is possible that in real time it is not the same as processing a set in the event of a cloud computing.

Geographical distribution - A computer program operates in a distributed environment so it is faster to deliver quality streaming services. The essence of fog computing is due to the lack of assistance with Quality Services at the end of the network

Protection and Privacy - Because the data contains encrypted information, IoT plays an important role in protecting that type of data ensuring protection from cyber hackers. It has its own security initiatives. Backup content on the fog platform is a way to reduce network traffic and improve backup time

Fog Computing in Smart Manufacturing

A system for monitoring machine health using the Fog Computing method was proposed by Wu et al [20]. To perform predictable analysis using machine learning algorithms and highly efficient computer services. The authors have used a generic architecture with three layers, but the main focus was on the machine learning curve. A production test program that uses deep communication networks was introduced by the authors when computer functions were loaded into Fog Nodes within buildings.

A novel model of test load balancing was presented by the authors who evaluated the performance of their buildings based on the design principles of Industry 4.0. A graph-based model of modeling and analysis of the Cyber-Physical system was introduced where they found a random network such as the CPS system behavior in the Fog Computing area. An inexpensive integration method using the MQTT protocol with Fog gate devices was proposed, which was intended to reduce power consumption in the Fog-based scheme by Peralta et.

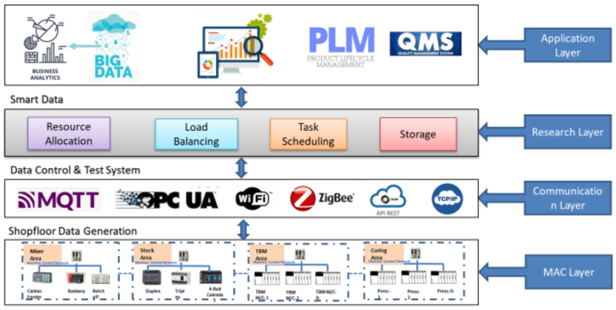

Figure 2 Fog Layer distribution

Fog Deployment Models

We may classify fog models based on ownership of fog infrastructure and sub-structures. We have four different types of fog models.

- Private fog: Private fog is developed, purchased, maintained and controlled by the business, third party or its variants. It can be installed on or off site. Private fog services are sold to be fully utilized by a single company.
- Public fog: : A public fog is owned, developed, and managed, or a combination, of a business, educational institution or government organization. It is planted on the premises of the fog suppliers. Public fog services are provided with open access by the public or the general public.
- Community fog: The public fog is developed, maintained and controlled by various public organizations, which may include third parties, or their affiliates. It can be installed inside or outside the premises and the services are provided specifically for use, usually by customers in a particular group of organizations with similar interests.
- Hybrid fog: Combined fog is a type of cloud computing that combines the use of public / private / public fog with a public / private cloud computer (i.e., a mixed cloud). It may be helpful due to the inaccuracies of the visible resources in the fog. As a result, the field is used in a mixed cloud to measure performance. The hybrid cloud is flexible, modular, and resources are accessible on demand.

Conclusion

Smart Factory has IoT sensors and trackers can enable optimal conditions for handling biomaterials and chemicals, ensuring flawless equipment operation numerous application running on the edges of the network have very different requirements and features make it a problem for resource allocation challenge. Apps that consume more bandwidth today they require very low latency requirements to operate efficiently and satisfactorily user experience. ML algorithm based Fog a computing has emerged to meet these network needs and delay requirements for cloud computing skills directly on the edge of the network. This paper approaches different algorithm and its benefits to implement fog computing.

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