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An Approach from Internet of Things to Cloud of Things using Fog Computing

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ABSTRACT: With the proliferation of Internet of Things (IoT) devices, there is an increasing demand for real-time data processing and analysis. However, the traditional cloud computing architecture is not well-suited for IoT applications due to its inherent limitations such as high latency, limited bandwidth, and high-power consumption. Fog computing has emerged as a promising solution that brings computation and storage capabilities closer to the edge of the network. This paper explores the transition from IoT to Cloud of Things (CoT) using Fog computing. We discuss the benefits and challenges of Fog computing and analyse its architecture and components. Additionally, we examine various use cases of Fog computing and discuss their advantages and limitations. We conclude by highlighting the potential of Fog computing to enable the transition from IoT to CoT.

KEYWORDS: Internet of thing, cloud of thing, fog computing, connected cars, smart grids, fog application

1. INTRODUCTION

Internet of thing consist of loosely connection of end devices to connect, process and store data in order to perform efficient and effective decision making.
The aim of this study is to explore the feasibility of transitioning from IoT to CoT using Fog computing and to evaluate the potential benefits and challenges of this approach for enabling efficient and scalable IoT applications.
The objectives of the study are follows:

1. To review the existing literature on Fog computing and its application in IoT and CoT.
2. To evaluate the technical requirements and challenges of implementing Fog computing for transitioning from IoT to CoT.
3. To analyze the performance and scalability of Fog computing in comparison to traditional cloud computing for IoT applications.
4. To assess the potential economic, social, and environmental impacts of Fog computing for IoT applications.
5. To propose a framework for implementing Fog computing in enabling the transition from IoT to CoT.

The research will answer the following question.

1. How can Fog computing enable the transition from IoT to CoT, and what are the technical requirements and challenges of implementing this approach?
2. What are the potential benefits and drawbacks of using Fog computing for IoT applications, and how does it compare to traditional cloud computing architectures?
3. What is the optimal configuration and deployment strategy for Fog computing in enabling efficient and scalable IoT applications?
4. How can Fog computing contribute to the development of smart cities, smart agriculture, and other IoT-driven sectors?
5. What are the economic, social, and environmental implications of adopting Fog computing for IoT applications, and how can they be addressed?

According to research that is held by cisco the number of connected devices will be doubled to population of the world, thus storing, managing and analysing the information generated by this connected device are difficult. The following figure show the number of connected devices versus the world population.

Table 1. Connected devices vs world population.

World population and number of connected devices			
No.	Year	Number of Connected Devices	World population
1	2003	6.3 billion	500 million
2	2010	6.8 billion	12.5 billion
3	2015	7.2 billion	25 billion
4	2020	7.6 billion	50 billion

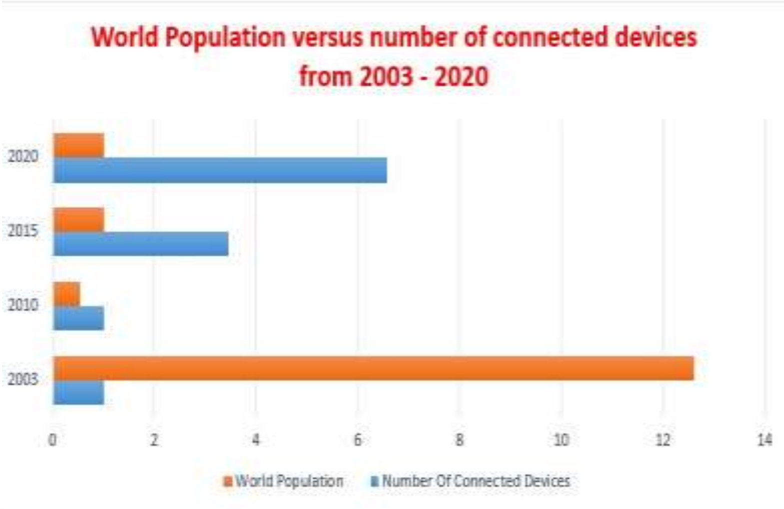

Figure 1 Connected devices vs world population

The IOT technology provide many opportunities and millions of Giga byte data, so storing and managing these massive amounts of data is difficult work and need high space for storing these amounts of data, so efficient mechanism should be considered for storing and analysing the amount of data. The other problem with the IOT technology is the security and reliably issues. Secure and reliable accessibility to these massive amounts of data is quite difficult task and need powerful mechanism to tackle the above issues.

One solution is to use cloud computing technology with the IOT devices to store and manage these massive amounts of data. Cloud computing provider, provides high space based on "pay as you go" to store and analyse the information generated by the IOT device, this technology integrates the technology of IOT and cloud computing which is known as cloud of thing or COT, that encamps both IOT technology and cloud computing facilities to connect the end devices with one another and store them generate data into the cloud for further processing and intelligent decision making. This solution sounds good but the problem with cloud of thing technology is latency for storing and retrieving is high, because the data generated by the IOT devices are stored in the cloud and it takes much time to retrieve the information. It means high latency is required to store and retrieve the data stored in the cloud and if there is low internet connection this may be a terrific problem because in real time application the time is very important. To solve this problem cisco, suggest another solution which is "fog computing" also known as fogging or fog computing or edge computing.

Fog computing tries to store the sensed data by the end devices in the edge of the network rather than a centralized data center that high latency is need to retrieve back the data to the end users, this will help the end device to store and retrieve data in high-speed manner, thus low latency is required. The edge may be a router or a switch or a smart gateway or dedicated fog computing device that are placed near to the end user to sense the generated information by the IOT devices. Fog computing also support the mobility computing resources, communication protocols, interface heterogeneity, cloud integration, and distribute analysis to address requirement of application that need low latency with a dense geographical distribution.

2. RESEARCH METHODOLOGY

The research methodology for this study on transitioning from IoT to CoT using Fog computing may involve the following steps:

1. Literature review: Conduct a comprehensive review of existing literature on Fog computing, IoT, and CoT to identify the key concepts, theories, and trends in this field.

2. Case studies: Analyse case studies of Fog computing implementations in IoT applications to understand the technical requirements and challenges of implementing this approach in practice.
3. Data collection: Collect data on the performance and scalability of Fog computing in comparison to traditional cloud computing architectures using simulation models, experimental setups, and other relevant methods.
4. Data analysis: Analyse the data collected to evaluate the potential benefits and drawbacks of using Fog computing for IoT applications, as well as its economic, social, and environmental implications.
5. Framework development: Develop a framework for implementing Fog computing in enabling the transition from IoT to CoT, based on the findings of the literature review, case studies, and data analysis.
6. Recommendations: Provide recommendations for policymakers and industry stakeholders on the adoption and implementation of Fog computing for IoT applications, based on the research findings and framework development. The research methodology may also involve a mix of qualitative and quantitative research methods, such as surveys, interviews, focus groups, and statistical analysis, to gather insights from different stakeholders and perspectives.

3. FOG COMPUTING CHARACTERISTICS

i. **Heterogeneity**: Fog Computing is a highly virtualized platform that yields compute, storage, and networking services between end devices and traditional Cloud Computing Data centers, typically, but not elite located at the edge of network. Compute, storage, and networking resources are the building blocks of both the Cloud and the Fog [11].

ii. **Edge Location**: The origin of fog computing focus to provide computation and analysis of information at the edge of the network rather than centralized data centres to provide low latency services.

iii. **Geographical Distribution:** In sharp contrast to the more centralized Cloud, the services and applications targeted by the Fog demand widely distributed deployments. The Fog, will play an active role in delivering high quality streaming to moving vehicles, through proxies along highways and tracks [12]

iv. **Large-scale sensor networks:** monitoring environments such video surveillances, smart grid, smart cities are examples of inherently distributed system, requiring distributed computing and storage resource [13].

v. **Support for mobility:** Fog computing application require to communicate with many end devices to sense them generate data, protocols such as LISP use to separate host identity for location identity.

vi. **Real-time interactions:** Important Fog applications involve real-time interactions rather than batch processing [13].

4. FOG COMPUTING APPLICATION

Fog computing encamps a wide range of applications that are listed follow:

a) connected devices:

The emergence of semi-automatic and self-propelled cars only creates a large amount of vehicle data. Owning cars independently requires a local capability to analyse specific information in real time, such as the environment, driving conditions, directions, and more. Other information may need to be returned to the manufacturer to help improve vehicle maintenance and / or track of vehicle use. The environment enables fog calculations to enable communication for all data sources, both on the edge (in the car) and on the end point (constructor).

b) Smart cities and Smart grids:

Smart cities and smart grids, such as connected cars, system tools, are increasingly using real-time data to make systems more efficient. Sometimes this information is in distant areas, so processing near the place of creation is necessary. Once again, the data must be collected from a large number of sensors. To solve both issues, the fuzzy computing architecture can be designed.

5. CLOUD COMPUTING CHALLENGES

1. Excessively data

There is massive amount of data generated by the cloud edges.

2. High latency required

A high latency is required to store and retrieve the data stored in the cloud data canters.

3. Resiliency impractical

The data security and privacy are unpredictable.

6. CLOUD COMPUTING CHALLENGES SOLVED BY THE FOG COMPUTING

Following table shows that how fog computing help cloud computing:

Table 2 Cloud vs fog

No.	Cloud computing challenges	Fog computing paradigm
1	Critical latency requirement	Fewer network hops
2	Data rich mobility	Data locality & local caches
3	Geographic diversity	Intelligence localized as appropriate.
4	Network bandwidth limit	Local processing / less core Net, Load
5	Reliability/Robustness	Fast Failover, local resp. in energy
6	Analytics challenges	Analytics & storage at the right tier
7	User data / geo privacy	Fog can aggregate user data

7. RESULT

The results of this study on are to demonstrate the potential of Fog computing in addressing the limitations of traditional cloud computing architectures for IoT applications. The study is to show that Fog computing can provide a more efficient and scalable approach to processing and analysing IoT data, while also reducing latency, improving security, and lowering costs. The study may also identify some of the technical requirements and challenges of implementing Fog computing for IoT applications, as well as the economic, social, and environmental implications of adopting this approach. Overall, the study is expected to contribute to a better understanding of the role of Fog computing in enabling the transition from IoT to CoT, and provide insights and recommendations for policymakers and industry stakeholders on the adoption and implementation of this approach.

8. CONCLUSIONS

Internet of thing consist of loosely connection of end devices to connect, process and store data in order to perform efficient and effective execution.

To store and analyse the data generated by the IOT devices are immersive storage, first solution can be cloud computing paradigm to overcome data storage and analyse problem.

But cloud computing requires high latency and high-speed internet connection to transfer data to the cloud data centre. second solution is promoted by the cisco which the fog computing architecture, fog computing stores the data near to the end user edge rather than cloud data centre to reduce the high latency to store and retrieve data back to the end user.

Fog computing provide many opportunities for instance; connected devices, smart grid, smart cities, smart health care services, smart traffic lights and video surveillance.

Fog computing also supports the cloud computing and solve the cloud computing challenges.

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