Intelligent Resource Management in Blockchain-Based Cloud Datacenters

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Abstract: Currently, many companies migrate business from their own servers to the cloud. The data centers consume tremendous energy every day, due to the high volume of transactions that varies due to the influx in the computational resources that enforces great attention and focus to be given in the energy efficiency dilemma. We emphasize and explore on the energy-aware resource management problem in cloud data centers, where green energy with unpredictable capacity is considered. By means we are proposing a robust blockchain-based decentralized resource management framework, we save the energy consumed by the request scheduler. In addition, we propose a reinforcement learning method embedded in a smart contract to further minimize the energy cost. Since the reinforcement learning method is informed from the historical knowledge, it relies on no request arrival and energy supply. Experimental results on Amazon Web Services (AWS) cluster traces and real-world electricity price show that our approach is able to reduce the data centers cost significantly compared with other benchmark algorithms.

Keywords —Blockchain, Decentralized, Reinforcement Learning, Robust, Smart contract, Transaction

I. INTRODUCTION

As a developer there are various aspects of product development that you can influence, and one of the key areas that have a longer-term impact on the entire business is your choice of cloud provider or data center. While the straight up dollar cost is relatively easy to calculate, you can also factor two environmental questions – how green are your cloud providers and how are they influencing the longer-term make-up of the electricity grid.

The hyper scale cloud providers (Amazon, Google and Microsoft) have a significant level of influence when it comes to purchasing electricity. They can impact both public policy and commercial perspectives on how it is generated. The primary public manifestation of this influence is via Power Purchases Agreements (PPAs).

Over the last few years each of the hyper scale providers have made strategic use of PPAs in the US market. In a number of cases, such as in Virginia, North Carolina and Texas, this is having a direct impact on the make-up of the electricity grid. If Amazon, Google or Microsoft call, the electricity companies they are listening.

II. RESOURCE MANAGEMENT

A. Public Policy Statements

Each of the hyperscale providers has made public policy statements about their current energy consumption and long-term goals. Suffice to say the direction of travel in terms of renewable energy is positive for all of them.

Provider	Current	Goal
AWS	AWS has 50% renewable energy for data centers in 2017	100% long term goal, no specific date
Google	Google has 100% renewable energy across data centers and offices (purchase offsets, includes non-public cloud)	–
Microsoft	100% Carbon Neutral	44% from wind, solar or hydro, aiming for 50% this year, 60% early 2020s

Table 1: Public Policy Statements

The sheer scale of the efforts of each of the providers is noteworthy, but Amazon deserves to be singled out – while their headline percentage is currently lower than the others, the focus on reaching 100% sustainable electricity, while still growing their business at current rates, is impressive.

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B. Data Center Locations & Renewable Targets

To understand the potential impact of the cloud providers on electricity demands and therefore the structure of the supply side networks, we need a clear picture of their primary locations worldwide.

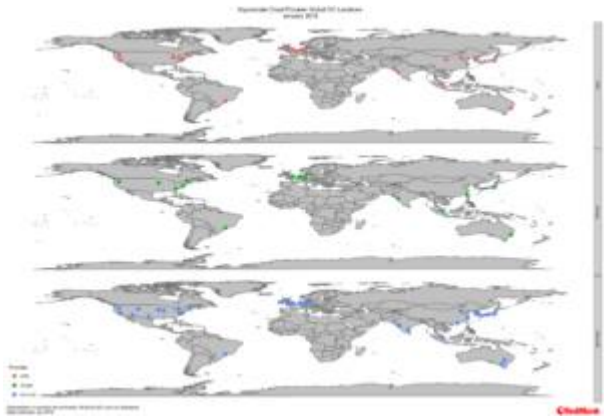

Figure 1: Data Center Location & Renewable Targets

It should be noted that the total number of locations does not imply wider availability. Microsoft is only beginning to roll out availability zones (AZ), whereas Amazon and Google have multiple AZs in each area indicated on the maps above. Microsoft has had a focus on geographic locality.

Outside of the US, the hyperscale providers are expanding in various regions, with clusters emerging in Canada, Ireland, Germany, United Kingdom, Benelux, India, China, South Korea, Japan and Australia. As noted above details on PPAs outside of the US are relatively limited, but we can look at the mix of renewables in each of the national power grids.

Electricity Production & Targets		
Country	**Current % Renewables**	**Goal (2020 and beyond)**
South Korea	6%	20% by 2030
Ireland	27.2% [2016]	33%
Canada	18.9% [2017]	No national target
United Kingdom	30% [2017 Q3]	30%
Germany	32.2% [2016]	35% by 2020
China (mainland)	25% [2016]	Hard to discern a specific target.
India	18%	20% by 2022
Japan	10%	24% by 2030 – Japan is also reopening nuclear plants
Australia	14% [2016]	17% by 2020 or beyond – Australia lowered its target from 20% in 2015
Belgium	15.8% [2016]	21%
Netherlands	12.5% [2016]	37%

Table 2: Electricity Production & Targets

Note: this table refers to electricity only; transport and heating significantly alter the numbers for total energy consumption in each country.

C. Direct Investment In & Purchase of Renewable Energy

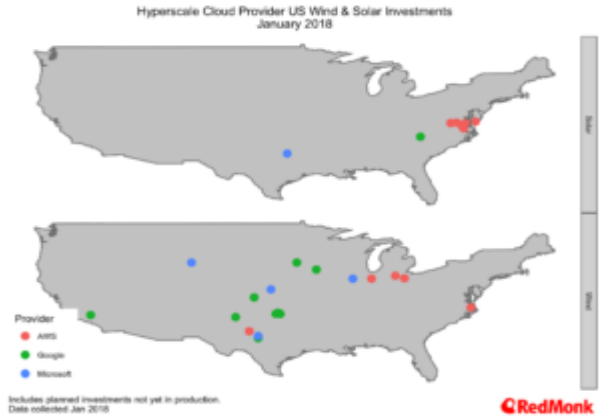

Figure 2: Hyperscale Cloud Provider US Wind & Solar Investments January 2018

As noted above, the hyperscale providers have been very public about their US investments in renewable and sustainable energy. Graphically, we can see specific geographic groupings, with Google focused on the mid-west, while Amazon is heavily weighted towards the east coast.

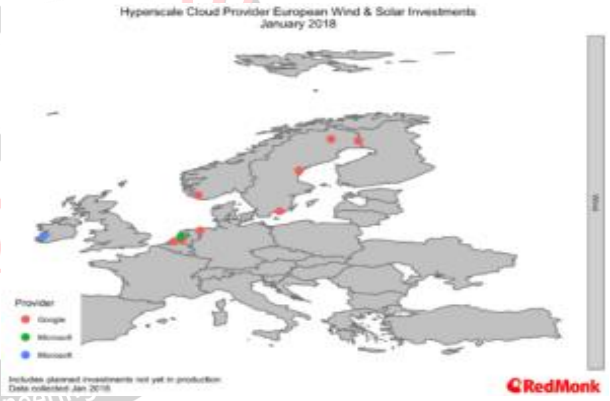

Figure 3: Hyperscale Cloud Provider European Wind & Solar Investments January 2018

The European story is more complex due to the nature of the market, and data about the PPAs signed is harder to come by. The hyperscale providers, along with a number of other large power consumers, have recently asked for significantly more regulatory alignment across the EU for PPAs, and an EU-wide goal of having renewables provide 35% of all energy. Such alignment would make it easier for firms to guarantee to purchase renewable energy, such as the recent Microsoft agreement in the Netherlands.

Elsewhere in the world there are no public investments in green energy listed, with the exception of Googles investment in Chilli, but we anticipate this will change as the providers engage further with local energy companies and regulators.

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Total Renewable Energy Purchases via PPAs – Jan 2018	
AWS	1150 MW
Google	2620 MW
Microsoft	759 MW

Table 3: Total Renewable Energy Purchases via PPAs

D. Data Centre Efficiency Investments

Each of the hyperscale cloud providers is keen to highlight their work on data center efficiency, and in no way should this be taken lightly – there is significant ongoing research and investment across all of these companies towards making their data centers more efficient.

But make no mistake here, it is clearly of both strategic and business importance for Amazon, Microsoft and Google to invest significantly in this area – we would have far more questions to ask if they were not making such investments.

III. METHODOLOGY

A. RL Mechanism

RL Mechanism is an approach learning what to do in different situations to maximize profit. The key elements of RL are state, action, reward, and agent. The learning process of an agent includes a series of actions and the corresponding reward. In each state, agent evaluates the expected profit of various possible actions by value function (i.e., value function is a function mapping state and action to reward). Then, the agent, according to a certain policy, selects an action to take, and the state thereafter is changed. The reward associated with the former state and the taken action is used to update the value function. Generally, the profit, also called return, is the accumulated reward that measures the benefit of a taken action in a certain state. The RL is an ideal solution to reduce the energy cost among complex DCs, because it does not need any prior knowledge. In our proposal, the idea is to migrate requests and VMs among DCs according to the historical migrating decisions' energy cost. We implement the idea by a smart contract, which is triggered by every incoming request. In other words, once a request submission or resource allocation happens, our cost minimization algorithm implemented by a smart contract will be triggered. In each learning iteration led by a request, DCs first select an action (migrates requests and their VMs to DCs). Then, the migration is performed. Finally, the new state and reward (DCs' load and energy cost) is obtained for learning. Specifically, actions contain all the possible migrations of requests and VMs among DCs, and states are the load situations that the DCs could achieve.

IV. CASE STUDY

Have you ever wondered that where did the phone that you use in your day-to-day life come from? or the clothes that you buy or the food that you eat? Apart from just going to shop, there's a whole other chain of different interlinked elements that work on delivering these products to you. This connected chain is called as Supply Chain.

Consider a clothing supply chain for instance. In clothing, textiles, and apparel manufacturing industries they involve a lot of labors as the demand for work . The estimated employ count in the industry is more than 60 million people globally. The term supply chain in the clothing sector is indicated as the back end of the industry. The supply chain in the clothing industry is made by connecting certain facts:

- The Raw material sources
- The Factories that use these raw materials and create final products
- The Distribution network that delivers these clothes to consumers

The clothing supply chain consists of millions of people along with tonnes of water, crops, chemicals, and oil worldwide. This makes it difficult for manufacturers to find where the different parts of their products come from. The demand for increased speed, high volume, and cheaper consumption is increasing day by day. Due to this, when the trade has valued the transparency of an ethical supply chain, the supply chain is compromised.

A. Supply Chain Challenges and Blockchain Solutions

Blockchain can be applied to many challenges of the Supply Chain industry such as complicated record keeping and tracking of products as a less corruptible and better-automated alternative to centralised databases. There are some ways in which blockchain can be useful in the supply chain industry. They are

a) Provenance Tracking

Big companies and organizations have a lot of details in their supply chains. Due to this, it becomes almost impossible to keep track of each and every record even for multinational corporations. The lack of transparency leads to cost and customer relations issues which ultimately dilutes the brand name.

In a blockchain-based supply chain management, product information can be accessed with the help of embedded sensors and RFID tags. It is made easy with record keeping and provenance tracking. The history of a product right from its origin to where it is in the present time can be traced through blockchain. Moreover, this type of accurate provenance tracking can be used to detect frauds in any part of the supply chain.

b) Cost Reduction

The live tracking of a product in a supply chain with the help of blockchain reduces the cost of moving items in a supply chain. According to a observations of supply chain workers conducted by APQC and the Digital Supply Chain Institute (DSCI), more than one-third of people recognized

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reduction of costs as the topmost benefit of application of Blockchain in supply chain management.

When blockchain is applied the additional costs occurring in the system are spontaneously reduced while still guaranteeing the security of transactions. The removal of the middlemen and intermediaries in the supply chain saves the risks of frauds, product duplicity and saves money too. Payments can be managed by end users within the supply chain by using crypto currencies rather than customers and suppliers rather than relying on EDI. Moreover, effectiveness will be improved and the risk of losing products will be reduced with accurate recordkeeping.

c) Establishing Trust

With trustworthy complex supply chains with many users is necessary for smooth operations. For instance, A manufacturer shares his products with suppliers, who should be able to depend on them for following factory safety standards. Also, when it comes to regulatory compliances such as custom enforcers, trust plays a vital role. The fixed nature of blockchain in the supply chain is well-designed to prevent tampering and establishing trust.

B. Benefits of Supply Chain with Blockchain

One of the most attracting benefits of using blockchain for data is that it lets the data to be more interoperable. Due to this, it becomes easier for companies to share information and data with manufacturers, suppliers, and vendors. Transparency in Blockchain helps reduce delays and disputes while preventing goods from getting stuck in the supply chain. As each product can be tracked in real-time, the chances of misplacements are rare.

Blockchain delivers scalability through which any large database is accessible from multiple locations from around the world. It also provides higher standards of security and the ability to customize according to the data feed.

Moreover, blockchain can be created in a private manner too which will allow the data to be accessed explicitly between the parties who have the permission for it.

The value of adopting blockchain technology can be taken from the fact that it has the potential to connect different ledgers and data points while maintaining the data integrity among multiple participants. The feature of transparent and immutable block chain technology make it useful for removing frauds in supply chain and maintaining the integrity of the system

Apart from this, the other benefits of applying Blockchain technology in the supply chain industry are:

1. Reduce or eliminate fraud and errors
2. Improve inventory management
3. Minimize courier costs
4. Reduce delays from paperwork
5. Identify issues faster
6. Increase consumer and partner trust

With its usage is increasing across the globe, blockchain technology seems like the solution to the problems of many industries today.

C. Implementation

Supply chain logistics include the design, planning, execution, control, and monitoring of goods and services journey activities adding value to the final product. Eventually built on intercommunication business networks, supply chains manage to provide the final product to the consumers through a series of actions, such as raw material extraction, manufacturing to build the product, distributing the product to middle-men (wholesalers, retailers), and allocating the product to the public. These kinds of activities are conveniently assumed in our solution as transactions of a blockchain network and the participants of the supply chain interact with each other through this network. Below are the different actors of a supply chain that are described briefly in order to give a typical perspective.

Figure 4: Supply Chain Roles (Actors) interacting with Blockchain Distributed Ledger Technology

Supply chain as one of the most populated industry holds certain use cases where the application of blockchain technology can bring a difference. A single shipment of goods can have at least 20–25 people or organizations in the process which leads to roughly 200 interactions between them thus, leading to a lengthy process.

If correctly applied, block chain technology can assure provenance tracking and traceability across the supply chain. This, successively, will lead to fewer counterfeiters and ensured safety in the processes. Block chain in this use case will also allow producers, transporters, and end-users to collect data, study the trends, and apply predictive monitoring process for better product experience.

Supply chain management includes the built in planning as well as the execution of different processes. This includes material flow, information flow as well as financial capital

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flow. The management of the streaming of goods, services, and information involving the storage and movement of raw materials, building products as well as full-fledged finished goods from one point to another is called as supply chain management. A supply chain within the SCM is a network of individual entities, organizations, businesses, resources as well as technologies that combine together in the manufacturing of a product or service.

Any progresses in supply chain, by first delivering the staple materials from a supplier to a manufacturer and finally end by delivering the final product to the consumer. Suitable implementation of supply chain management can yield in benefits like increased sales and revenues, decreased frauds and overhead costs, quality improvisation. Moreover, this will also lead to accelerating production and distribution.

While all of this seems simple in theory, practically maintaining a supply chain is a tedious task even for small businesses. The interconnectivity of various elements in the supply chain gradually becomes more inefficient when a business grows. To resolve this fruitlessness and save company's money, different technologies like AI and Machine learning are being applied to SCM. Among this, blockchain is discovering new ways to change the overall game.

V. RESULT

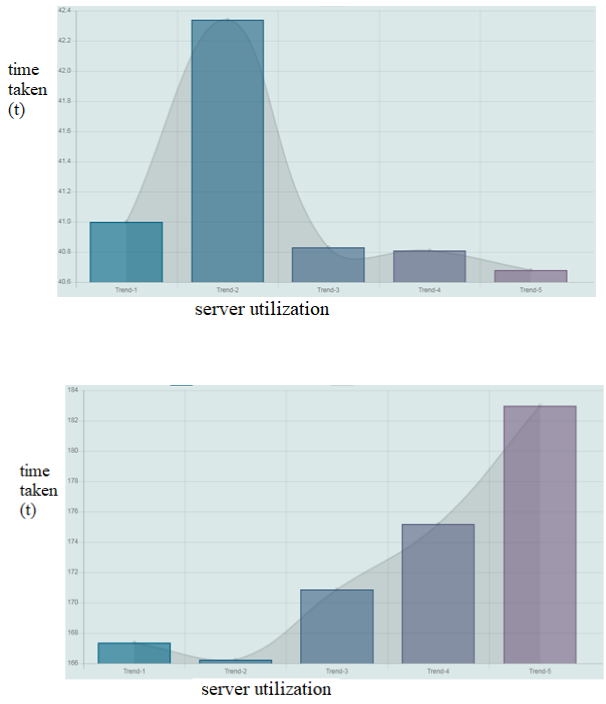

Figure 5: The chart provides the details on Trends of the server utilization on various requests.

On testing the implementation of Block chain in the supply chain management we could find that the time taken by each server to process the data using RL-based energy cost minimization method considers jointly green and migration energy.

VI. CONCLUSION

Most large enterprises will struggle both to run data centers as efficiently as the hyper scale providers and to leverage their data centers to influence public policy or the make-up of power grids.

If there are green criteria to your projects, considering one of the hyper scale providers will serve you well.

Blockchain has established its potential to bring out positive changes in many industries and businesses till date including the supply chain industry. In reality, the supply chain management is one of the most obvious and useful applications of Blockchain technology, therefore, we can expect it to grow at a very fast pace in the near future. The origin of successful operation of a supply chain management system is to keep a robust, transparent and end-to-end communication.

Industries are exploring the ways to filter the manner their supply chains currently work & adopt the change that the Blockchain technology has to deliver. Once the organizations see the bigger picture, they'll gradually go through the hassle of applying advanced systems embedded with blockchain in order to result bigger benefits in the future. Depositing the paperwork and centralized databases will bring effective change in terms of high rewards and increased performance among the supply chain teams. This can be achieved if and only if the supply chain teams in place take notice of the latest technology trends in the blockchain space and find feasible ways to adopt the technology in their existing systems. Using of blockchain in supply chain management will be a game changer by eliminating the vulnerabilities and inefficiencies of the current system.

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