A STUDY ON SELECTION OF DATA CENTER LOCATIONS

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ABSTRACT: Cloud computing has been a topic of discussion, research, study, analysis for the last decade. And in the coming years it will gain more importance and more of its new aspects will be explored. The services of cloud computing has been provided via different Data Centers. The Cloud Service Providers build their own data centers and provide different types of services. This paper focuses on one of the key issues and a challenge that is an integral part of data centers. The question is what is a suitable location for building data centers?

KEYWORDS: Cloud Service Provider (CSP), Data Center (DC), Green Cloud Computing, Quality-of-Services (QoS).

I. INTRODUCTION

The new era of computation has been associated with the field of cloud computing. It has become a blessing for many. Individuals, educational institutes, research organization, enterprises, large industries become dependent on it. The huge cost of buying, installing and maintaining hardware and software components has shifted to Cloud Service Providers (CSP). CSPs use data centers (DC) to provide different types of services, e.g. Software-as-a-service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) over the internet. Now, one of the major concerns of CSP's is regarding appropriate geographical location of Data Centers. Before planning about what services will be provided and how?, the first and foremost thing to think is what location on earth would be suitable to build a DC. Several issues need to be considered when selecting a location for building DC. The following sections highlights on these issues.

II. KEY ISSUES AND THE CHALLENGES

To find a best possible geographical location to build DC is not an easy task. Before going into the details of these issues, we would like to categorize the types of issues (see fig. 1).

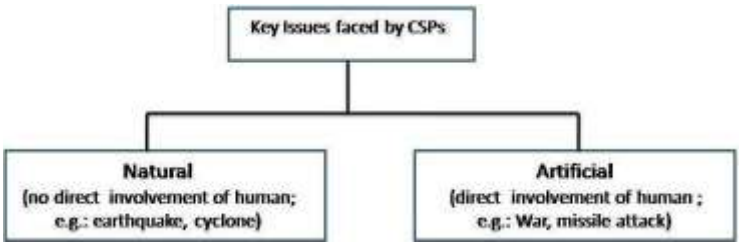

Fig. 1. Classification of key issues in building DC

In the following section these issues are elaborated.

1. **Climate/Weather of Geographical Areas:** One of the major issues regarding the location of DC is the overall condition of climate/weather of a geographic location. Around the globe, we can find areas with different types of climate conditions, that if taken into considerations, play a significant role in the selection of DC location. The CSPs can accumulate all these information from respective country's/province's government, regional meteorological department etc. For example,
   a) Areas where the weather condition is too hot (e.g., desert) is never a suitable location for building a DC. Because that will have an adverse effect on DC. Since the CSPs already need to spend significant amount of
   b) Areas that are prone to earthquake may not be a suitable location for building DC. Because, the kind of loss that may hit a geographical area, is fatal, because it is not only the loss of data stored in DC servers, but also the entire infrastructure that can crash down along with the loss of human life too. Although, it is not possible to make a prediction about earthquake beforehand, but still through rigorous study by geologists, they marked some locations on earth, where there are frequent numbers of earthquakes during any year.
   c) On the earth, there are some places which are prone to typhoon, cyclone, hurricane etc. These natural calamities have a severe effect on human civilization, and consequently DC won't be an exception. So, it is better CSPs to avoid those vulnerable areas.
   d) It is better to stay very far away from locations having volcanos/ frequent volcanic eruptions. Hopefully it won't require an explanation further.

Apart from the above discussed points, there are many other different types of natural catastrophic events in which we have very little to do. For example, incidents like Tsunami, wildfires, meteor shower etc. For these kinds of situations, it is better to prepare about what to do after the incidents if they occur, rather try to prevent it.

2. **Physical Distance Between DC and Consumer:** One most the most significant issues is the physical distance between a cloud consumer and the DC. Because, all the kinds of services (XaaS, X is S or P or I) that a consumer wants, will be fulfilled with the help of DC. So, the geographic location between consumers plays an important role in the QoS. If the physical distance between a cloud user and a DC is very long (e.g., two different countries/continents), then quality of services provided may drop due to many reasons (e.g., delay). To avoid these kinds of problems in case of data access (e.g., email, documents etc.), CSPs use the technique of data replication. In other words, data is replicated in multiple DCs located at different geographic location, so that a user does not feel the lag in accessing data, if he moves to a different location (e.g., another country/continent) from the location he created the data in DC.
   In this respect, another important aspect is that, while selecting a location for building a data center, it would better to see whether there is an **actual** need of building DC in that location. For example, if within **few square miles** of a DC location, if there is hardly any number of education institutes (e.g., colleges, universities, research institutes) or business hubs or share market centers etc (e.g., a healthy consumer of cloud services), then building a DC in such location would not be a great choice. Because institutions like these are expected to use a significant number of resources in DC, making the decision of building DC near these institutes will be wise.
   But, in reality there are number of questionable issues for the CSPs that have been haunting them, these are---
   how many copies of data will be kept in differently located DCs? Whether in actual, the data will be accessed from a different location **ever**? How many frequent a data will be accessed from different geographic location? From how many different locations the data will be accessed? These are some challenging issues for any CSP.

3. **Availability of Other Sources of Energy:** As we know an enormous amount of electricity is needed to per year to run a DC, it has already become an issue of concern for CSPs. Not only they are concerned about the monetary amount of electricity bill, but also the need of more electricity power comes into the scenario. Because more and more equipments are added into the DC; like increase in the number of servers, cooling systems, routers, switches etc. And also the fact CSPs are comply to build new DC and they are in search of new geographic locations on earth. Consequently, that new DC consumes huge amount of electricity too.
   As a consequence, it has become a practice of CSPs to minimize the amount of electricity consumption. There is no problem with it. CSPs are implementing techniques to reduce energy consumption. As a result a new era of research has come up—Green Cloud Computing. But it seems to be a never ending race. Because in one hand, if CSPs are somehow able to reduce the energy consumption by DCs, on the other hand, requirement of building another new DC has come up. Requirement of building new DC will always be there, because the amount of data in our world is increasing with an extreme high rate. Thus, besides implementing the techniques to reduce energy consumption, a very good and more effective approach would be to look for available other energy sources in the nature, which does not pollute the nature badly. Hence, we must think about the available alternate sources of energy form nature. It may be the case, the amount of energy gain from these alternate sources of energy is not sufficient to run a DC. But still, if some of the portions of a DC (e.g., the cooling system etc.) can be run by these alternate energy sources then at least it will be much better situation than the existing one. Therefore, whenever a DC is to be build, a CSP must utilize the available alternate energy sources. Explaining about each of these alternate sources of energy is beyond the scope of this paper. The following list gives a brief idea on some of the alternate energy sources form nature:-

   a) **Solar Energy**: Solar energy is one of the vastly available alternate sources of energy. It is also comparatively cheap resource of energy in terms of cost (getting, implementing and maintain). And increasingly, this particular source of energy becomes more and more popular between all types of energy consumers (from industries to household). One inherent advantage of DC architecture is that it can use this particular source of energy in a very effective way. Since, a DC occupies a large geographic area (e.g., few hundreds of thousands of sq.ft.), solar panels can be easily placed on rooftop of a DC, and utilize the solar energy efficiently.
   b) **Wind Energy:** Wind power is the use of air flow through wind turbines to mechanically power generators for electricity. Thus, CSPs can think of this option of alternate energy as well. One may say that building infrastructures for wind power stations becomes an additional cost for CSPs. But this is one time investment and the biggest plus point with it, this method does not produces no greenhouse gas emissions, no need to supply water to run it. Another point is that CSPs may build DC near the land where wind energy station is already there.
   c) **Geothermal Energy:** It is the thermal energy stored in the earth. This source of energy may not be as popular as the solar energy, but it has a major role to play in the field of electricity in future generation. It is

environment friendly, sustainable, reliable and more importantly cost-effective. In 2013, 11700 megawatts (MW) of geothermal power is used worldwide.

d) Hydroelectricity: This form of energy refers to the electricity generated through the use of falling or flowing water. In 2015 hydropower generated 16.6% of the world's total electricity.

It is the case that, not all the above mentioned alternate sources of energy are available at any one place. Thus, it is up to the choice of a CSP, that which one of these to use efficiently as an additional source of energy in DC.

4. **Architectural Issues:** In this aspect, the entire architecture of a DC has to be very strong. In other words, the architectural strength of a building (DC) has to be very strong, so that it can bear issues like minor level earthquakes, effect of storm etc.
5. **Other Non-Negligible Issues:** Apart from all the issues discussed above, there are some issues which are completely undesirable, but not in our full control always. For example ---
   a) Crash of an airplane, helicopter at the location of DC, can go miserably wrong.
   b) Another important issue is--- Warfare situations between countries. In such situation, a DC may be completely annihilated intentionally/unintentionally.
   c) Any attack by human being/machine, like suicide bomb attack is also very dangerous for a DC.

III. RELATED WORK

Some of the work has been done in this topic. Some of the locations that must be avoided [1] are: a) below sea level; b) in the basement; c) large metropolitan area etc. In [2], several issues including the different types of natural disasters and different factors regarding workforce and business climate has been discussed.

IV. CONCLUSION

This paper presents the key issues related data center's geographic locations that must be taken care by CSPs while building data centers. In the above mentioned issues, there are some which we cannot control (e.g., earthquake).They are not explicitly in our hands. But some other issues (e.g., warfare, carbon footprints) are in the control of human beings. Thus, to make the data centers safer and secure our aim should be, to minimize, prevent, control the fatal effects of malicious activities made by human civilization.

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