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Fog Based Cloud Computing: AReview

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Abstract: Customization of services and control of services at the edge of cloud end points is becoming necessarily due to maturity of cloud based revenue models. Last mile resource provisioning is now critical for better levels of quality of service.Fog or edge computing is an emerging paradigm that can address these issues. This paper discusses, the various milestones for understanding the current status of fog/edge computing. In the introductory section, the authors discuss the beginning of specialization of computing devices for application specific work. Then, the other parts of the paper discuss various reasons to have multiple power profiles for load and power management.Typically, when residue power is become low, a device may reduce its load or it would activate its load balancing policy. This research work intends to investigate the fog based cloud computing energy/power needs. When caching is used to optimize the load and increase response time of the applications.

Keywords:Cloud computing, fog computing, sensors, Internet of Things(IoT),power profiles.

I. INTRODUCTION

Computer network's architectures have undergone many changes since the birth if first computer.But in the latter half of 1980, there was a need to rethink various kinds of computers and architectures. The computing power and memory power was increasing as per, Moore law[1].But, the development in hardware with respect software was not happening at the same pace. Initially, the software industry was slow in progress and every year new approaches, and new architectures were coming in the industry to solve business enterprise problems. This was real-life scenarios with technology. In the beginning, various models of client-server architecture came up. These client- server architectures were either defined based on their hardware or based on their software approaches. If, a specialized server was installed or deployed to handle various heavy duty tasks. The machine is called the "server" as it serves the other clients (which a computer having light weight task for processing). This division of labor between the computing machines gave birth to the concept of "thin clients" and "fat server" and later collection of these was called "farm servers" or the data centers. These data centers are the places where the storage, computing power and network infrastructure resides for running large scale enterprise business operations, which runs from various geo- distributed location to form cloud networks. As the progress happened the paradigm shifted from standalone/desktop applications towards client- server Due to the explosion of technologies related to Internet of Things (IoT). There are multiple competing standard architecture which needs to be accessed for building a particular system. Depending upon the application and situation the IoT may consist of groups of computers (servers, clients) and the group of sensors interacting with each other to full fill business objectives.

Till date, cloud computing has been the norm of the industry for implementing business enterprise application that has conventional data storage and computing needs. But with the inclusion of a large number of sensor types such as gesture sensors, medical sensors, work and force sensors, velocity and accelerometer sensors, tactile sensors, thickness and lens sensors, optical sensors and thermal sensors. The need architecture which may be a single tier, two tier, three tier or n tier applications.

These architectures gave birth to new data standard for data exchange such as XML and JSON. Such standards were operated with the help of web services[2] andweb socket, RPC call[3] is also used. Hence, there was a need for new kind of integration paradigm which would receive or send data from multiple locations, different platforms, and technology stacks. Currently, there are new technologies that help us to integrate with multiple devices having different protocols such as Bluetooth, satellite, Wi-Fi, Ethernet[4] and RF[5].Because of such technological advancements, sensors can be now connected to the web even if they are in motion or based on mobile communication architecture. Such arrangement can be safely called cloud computing and grid computing paradigm.

From the current literature, it can also be inferred thatthe real development in computer science will come from software side not from hardware. It is a known historical fact, after Pentium IV the computer scientists were unable to develop Pentium V due to physical limits of the material used to make computer processors and logical units. Now, most of the computers have parallel architectures, which mean that it has multiple cores to process tasks in parallel with programming paradigm such as Map-Reduce, Task Prioritization, Task Scheduling algorithms etc. In this process "distributed data flow" programming model has become most popular.

for resource management at last mile or edge becomes important. Due to this fact energy management, task management, and load management need to be readdressed to suit the capacities of devices deployed at the edge of the clouds. The need arises due to the fact that most of the sensors whether are based on the optical, thermal, electromagnetic pulse, piezoelectric or chemical based are readily available in the market that is portable in nature and are based on energy aware profiles like Bluetooth(BLE) [7]. These sensors have rechargeable batteries or have a constant source of energy depending upon their applications.

Portablemicrowave, radars, portable ultrasonic machines [8] and impulse detectors [9] are employed in vast areas of medicine, security, mining applications. Therefore, their basic requirement is to maintain a steady flow of the stimuli data to the server. The medical grade applications require very tight tolerance related to delay and jitter and may be deployed in remote villages. This necessity gave birth to new resource management strategies for a system to become successful. Therefore, in such cases, fog computing will be a helpful and certain level of computational load can also be processed before the data finally reaches the cloud data servers on data may be cached.

The sensors that measure distances, proximity, velocity, rotatory moments, inertia force, inclinations, angular gradient [10]etc. may be deployed in remote areas and may be mobile in nature. Such group of sensors may require and additional deployment strategies, energy management techniques and load sharing methods for them to be successful as a technology. The sensors that are in motion typically have primary or secondary battery cells as their source of energy which cannot be recharged easily. Therefore, these sensors [Fig.1.] need to work along with the cloud with a high degree of constraints and issues. These sensors communicate via Bluetooth, Wi-Fi, different radio frequencies and various RF(radio frequency) bands that make them fit for fog computing. Since these sensors are highly sensitive and need to be highly respondingin their function. All this leads to high degree of either machine to machine interaction or human to machine interaction. Hence, the higher degree of interaction means the necessity of edge/fog computing.

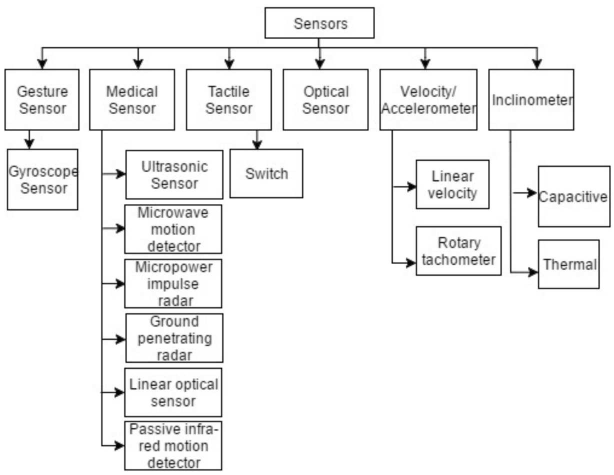

Fig.1. Different types of sensors

1. Gesture sensor[11]: The purpose of this sensor is to make sense of the sequence of actions mathematically. The body gestures may come from movements of hand, face or a full body motion. A gesture sensor needs to be trained with gesture data and connected with cloud platform, either by Bluetooth (BLE) or Wi-Fi connectivity device. Its usage is always in time sensitive application. Hence, may require special attention to take care of latency, mobility, real-time interactions along with wireless last mile connectivity.

1.1 Gyroscope sensor: Gyro sensors, also known as angular rate sensors or angular velocity sensors are devices that sense angular velocity.

2. Medical sensor[12]: A device that response to a physical stimulus (as heat, light, sound, pressure) and transmit a resulting impulse (as for measurement or operating a control). These sensors may require optimization of operational expenses, agility and strict QoS conditions. Hence if these devices may require fog computing infrastructure incorporation.

2.1 Ultrasonic sensor: These sensors analyze the sound, echo produced by the device for computing distance and time interval between the source and destination (object). In case such sensors are deployed as portable and are working at the periphery of the cloud it will require for computing infrastructure.

2.2 Microwave motion detector: This device analyses the motion in the objects by using the concept of sending and receiving microwave signals.

2.3 Micropower impulse radar: It is low power ultra wideband radar used for sensing and measuring distances to objects in proximity to each other.

2.4 Ground penetrating radar: It is a tool that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band of the radio spectrum, and detects the reflected signal from the subsurface structure.

2.5 Passive infrared motion detector: A passive infrared sensor (PIR sensors) is electronic that measures infrared light radiating from objects in its field of view.

3. Tactile sensor [13]: It is a device that measures information arising from physical interaction with its environment.

3.1 Switch: It is device for making and breaking the connection in an electric circuit.

4. Optical sensor[14]: Optical sensors are electronic detectors that convert light or a change in light into an electronic signal.

5. Velocity/Accelerometer [15]: It is a sensor that responds to velocity rather than absolute position. Since, these sensors are deployed in machines that are working in either in linear motion, velocity or at the same angle. It would definitely require special attention to maintain data logging and consistent connectivity, caching with primary and secondary servers in the networks.

5.1 Linear velocity: LVTs are kind of speed sensors which are usually used to measure the speed of small motion.

5.2 Rotary tachometer: It is a sender device used for reading the speed of a vehicle's wheel rotation.

6. Inclinometers [16]: It is an instrument for measuring angles of slope, elevation or depression of an object with respect to gravity.

6.1 Capacitive: It is a technology based on capacitive coupling that can detect and measure anything that is conductive or has a dielectric different from air. Capacitive sensors can also replace mechanical buttons.

6.2 Thermal: A device that detects temperature. When deployed in remote field or in sum industrial locations will require additional way to aggregate data over long range networks distance, hence the need for fog computing.

A. The Need For Having Multiple Power Profile In a Device

It is apparent from the last section, that each sensor type requires a special attention to maintain its resources and the network as the whole need different management strategy to maintain devices at the edges of a network. As it mainly, comprises of sensors that are constrained by theirresources.The table review of power profile policies given in current, research works.

1. LUFCS(Lowest Utilization First Component Selection Policy) [17]:This policy works on the principle of identifying important and less important tasks, components working in the device.The moment there is need for optimization. The device shuts down the less important task to overcome the utilization constrain.

2. LPFCS(Lowest Price First Component Selection Policy) [17]: This policy works on the principle of discount, whenever, there is a need for optimization, the device shuts components/tasks that are low in discount. Thus, the service provider saves more energy with fewer discounts.

3. HUPRFCS(Highest Utilization and Price Ratio First ComponentSelection Policy)[17]:This policy works on the basis of two parameters pricing ratio (utilization cost per unit) and discount. In this policy the optimization means deactivating components having small discount but high utilization.

4. PCO(VM Placement and Consolidation Algorithm)[17]:It is an adaptive heuristic based policy for dynamic placement of VMs to optimize energy consumption. This algorithm sorts the jobs/tasks/components based on decreasing order of their current CPU utilization and then increasing the least power consumption due to this optimization.

5. NUFCS(Nearest Utilization First Component Selection Policy) [17]: This policy works on finding a single component in the component list to deactivate in pursue of energy optimization. The single task/component has the nearest utilization in comparison to other tasks.

II. LITERATURE REVIEW

Due to ever growing size of mobile services, power management and the problems of elastic utilization of resources need more attention. The last section, gave various types of power profiles or policies that a sub-network of devices at the edge of the conventional cloud requires. In this section, a light will be thrown on running the edge network more efficient with use of caching schemes, efficient task management of resource monitoring. The following Table 1 gives an overview of methods that can further enhance the quality of service(QoS).The QoS metric defines the quality related to working of the fog network. The performance is quantified by an agreement between the service provider and customer. The agreement gives the definition of each factor, for example, how much delay/jitter is tolerable to the customer at given price/subscription of the service.

Table 1. Parameters wise review

Parameter	Author	Problem undertaken	Method/ Technique	Outcomes
Energy efficiency	Siming Wang et al. [18]	Energy conservation at the edge of cloud infrastructure.	Cache the content, use subset of social influences and popularity of the content to cachin.	• Reduced latency, • Better energy efficiency at particular threshold, • Increased QoS level.
Power consumption and latency	Jessica Queis et al. [19]	Increase QoE(Quality of Experience) of the ultra-dense network by using fog based methods and deployment.	Workload balancing by local clustering of resources for the set of users.	High user's experiences in terms of user's satisfaction and moderation of power consumption along with reduced latency for a small cell cloud, thus higher degree of quality of experience.
Payload and energy consumption	Nidhi Jain Kansal et al. [20]	Minimization of resource utilization for increasing energy efficiency and reduce carbon emission.	Conduct a review of all the methods, techniques used in cloud, small and large scale distributed networks and identify gaps to purpose better solution.	Increased awareness on how to overcome issue related to load balancing in multiple conditions and deployments.
Efficiency	Xiao Chen et al. [21]	Design vehicular data scheduling policy for better efficiency.	A case study based performance evaluation process Algebra PEPA Algorithm (compositional formal method).	Finding reveals the said algorithm is numerically stable and helps in increasing the efficiency dynamically in terms of better scheduling of workloads in the fog networks.

Latency,network congestion and cost	Harshit Gupta et al. [22]	Design a simulator for cloud computing and validate the working.	Used of case study method to check performance and validate the outcome of the simulator.	Case study/result reveals that computing reduces delay metric in the cloud and also leads to:- • Reduced latency at the edge, • Reduced energy utilization, • Reduced overall resource utilization.
Energy consumption	Dimitar-Minovski et al. [23]	Development of autonomous network management system (NMS) which operates in with retrieves power consumption data from the devices part of network infrastructure.	Built computational power models to compute power distribution units and management information based.	• Better degree of energy efficiency. • Improved QoS.
Power consumption	Victor Shnayder et al. [24]	Build a scalable simulator to model power consumption a large scale sensor deployment.	Build software and hardware power models. Do CPU profiling and power state of sensors and other devices.	• Trace-based simulation experimentation, • Simulated and measured results that match in almost all cases of experimentation, • Can simulate surge runs etc with respect to energy consumption modeling.
Energy consumption and cost	Aman-preetKaur et al. [25]	Review the contemporary load balancing methods employed in Cloud.	Identification of Challenges and gaps using systematic literature survey method.	Resources are allocated to application requests along with balancing the workload among the VMs to ensure no node is underutilized or over utilized.
Load balancing	Aman-preetKaur et al. [26]	Minimization of Energy and increase in throughput capacity of the cloud network.	Particle Swarm Optimization has been used for load balancing. The authors have used cloudsim simulator for demonstrating their work. The optimization has been carried out for throughtput and energy.	The work is compared with the Centralized mechanism of load balancing and shows lower energy consumption and increased throughput capacity with PSO.

III. KEY CHALLENGES IDENTIFIED

After the systematic review of the sensors, that may become part of fog computing and other aspects such as power/energy etc, following issues and challenges can be pointed out.

1. The current business systems should work with multiple network protocols and must also work with multiple data formats and exchange standards.
2. The system should be able to work with the heterogeneous collection of devices which may have different levels of energy and constraints.
3. The system should be able to work with multiple sensing technologies whose output may be analog in nature or it may require boosters, repeaters for signal conditioning and propagation.
4. The system should be able to work with multiple cryptographic technologies that secure the network of heterogeneous devices.
5. The network as a whole should be able to work in harmony with devices having different sleep and snooze cycles.
6. The system should be able to incorporate and accommodate multiple environmental conditions and scenarios for connecting to cloud servers.
7. The system as a whole should be able to monitor and audit its energy resources meticulously so that energy constraint devices do not create network voids and die off.

8. The system should be able to incorporate, aggregate and collate data from moving devices such as techno meter etc.

IV. CONCLUSION

In this paper, the main milestones through which computer science industry has gone through in the context of fog computing's have been discussed. It was found due to the explosion of sensor deployments across the world, the response sensitive applications need to overcome the problems of latency and jitter. Such applications require low latency, as well as the very low level of delay/jitter[27] and the client server distance, cannot be more than one or two hops. Such cases are mostly related to sensor-based applications where location awareness, geographic distribution and last mile network topography is dynamic in nature. Hence, the need to optimize the network resources more frequently as compared to the network resources which have a client-server architecture that allows multiple hops with the certain degree of tolerance in latency and jitter is allowed. The need for fog computing also arises from the fact that the main source of data is from sensors and each sensor may be having different stimuli response and complex event model. This impacts the overall scheduling of task and load balancing.

V. FUTURESCOPE

After conducting this systematic literature review,
It was found that there are a large number of devices that may require profiling of their battery or energy needs to maintain business continuity. There always a need to manage energy sources as the sensors have constraint battery power as they are powered with primary cells. Therefore, to avoid network void issues there is a need to do the energy audit of all the resources periodically as it would impact the schedule of tasks. Therefore, for future direction it is suggested that algorithms should be built that consider load balancing as the main criteria for resource management and for building power profile polices, for example, we can build an algorithms that uses the concept of nearest cache distance algorithm for managing cloud and sensor resources for minimizing turnaround time, rather make components on/off based on discount or price to maintain optimal resources.

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