Survey on Cloud Based Robotics Architecture, Challenges and Applications

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Abstract: The emergence of the cloud computing, and the other advanced technologies has made possible the extension of the computing and the data distribution competencies of the robotics that are networked by developing an cloud based robotic architecture by utilizing both the centralized and decentralized cloud that is manages the machine to cloud and the machine to machine communication respectively. The incorporation of the robotic system with the cloud makes probable the designing of the cost effective robotic architecture that enjoys the enhanced efficiency and a heightened real- time performance. This cloud based robotics designed by amalgamation of robotics and the cloud technologies empowers the web enabled robots to access the services of cloud on the fly. The paper is a survey about the cloud based robotic architecture, explaining the forces that necessitate the robotics merged with the cloud, its application and the major concerns and the challenges endured in the robotics that is integrated with the cloud. The paper scopes to provide a detailed study on the changes influenced by the cloud computing over the industrial robots.

Keywords: Robotics, Cloud Computing, Cloud Based Robotics, Big Data, Internet of Things, Open Source, Challenges and Applications

1. Introduction

The robotics that plays a vital role in automating the daily routines that are carried out regularly, the progress in the robots development has increased at a rapid pace in the industries and this has caused the robots that are programmed to reach a heightened performance in the real time providing a better compatibility, accuracy and robustness. The network framed using robots is the cluster of robots, where every robots I it is referred to as a node or a data point, these cluster of robots are linked using the either the wired or wireless communication. The robots are comprised of number sensing elements and the capabilities of decision making to perform the tasks in a more proficient way. The developments of the more advanced technologies have made the robotics to be utilized in a wide range of application such as the "analytical services, global

10

Ubiquitous Computing
Communication Technologies

positioning system, artificial intelligence biometric sensors, language processing, and atmospheric sensing and so on. But the memory in the robots are insufficient and very low for processing and storing the information's, to bring down the severity in the processing and storing the Robotics are integrated with the cloud that renders an on demand service to the devices such as robots [1-2].

The cloud delivers services on pay as you go terms to the devices as well as the collective group of people. These could be categorized based type of services provided by the cloud as the software as service also known as the SaaS, infrastructure as services-IaaS and the platform as services-PaaS all these services rendered by the cloud are hosted by the cloud from the servers of the provider and the propelled into the users device based on their request. Enormous storage capacities and the elastic nature of the cloud computing makes it compatible for a wide range of industrial and business applications. The cloud finds it way in the robotics as the idea behind the traditional standalone robots and the networked robots were well suited, cost effective and efficient for the static environment and were a failure when used in the dynamic environment with the scalable requirements due to their limitations endured in the manipulations done on board. However the rapid advancements and the newly emerging technologies have made the robots up gradation essential. This paved way for the merging of the cloud computing with the robotics to form a novel term cloud robotics as the sharing of resources and the cost effectiveness was the important issues that are to be taken into consideration. The concept behind the development was basically to bring down the production cost and enhance the throughput. The figure.1 below shows the three strategies of cloud robotics [3-5].
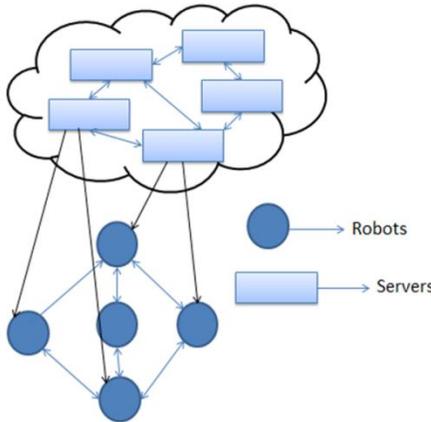

Figure 1. (a) Peer based Frame Work for Computation

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Communication Technologies

In Figure 1. (a) Peer based Frame Work for Computation the robotic network are directly connected to the cloud paradigm and provides a moderate robustness and interoperability with the high mobility
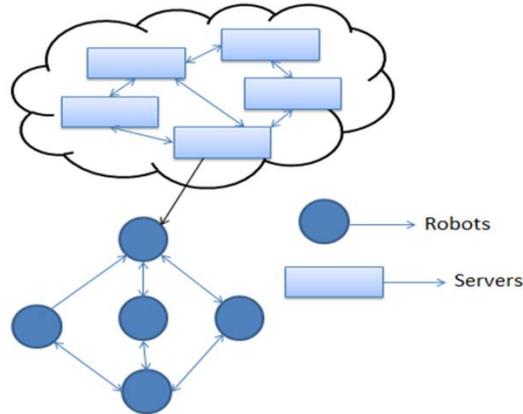

Figure 1. (b) Proxy based Frame Work for Computation

In Figure 1. (b) Proxy based frame work "the VM unit and the Robotic network in the cloud paradigm masters and maintains the bridge in receiving and distributing the task in the collaborative manner" providing a lower level of robustness with high interoperability and medium mobility.
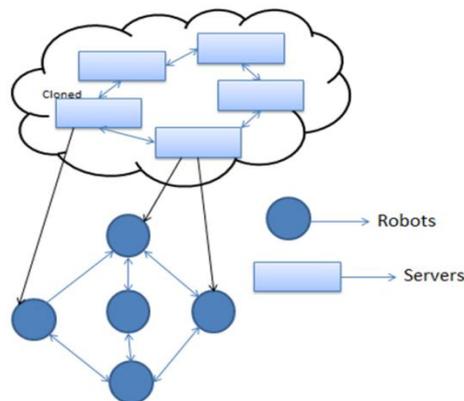

Figure 1. (c)Clone based Frame Work for Computation

12

Whereas in Figure 1. (c) Clone based frame work for computation "where each and every robot has a copy or clone in the cloud and the jobs are assigned to the robot itself or to its clone". The clone based provides a heightened robustness with the low interoperability and low mobility. Every computational architecture has its own merits and demerits in the varying scenarios, "The models are always implemented depending on the system resource availability, application requirements and state of networks on the basis of the amount of the work load"[7-9].

The paper organizes a survey on the cloud based robotic architecture, studying the need and the driving force behind the robotic architecture and further presenting the challenges endured and the applications of the robotics, with the complete study of the cloud robotics architecture in section 2, The Enabling forces of Cloud Robotics 3, the major concerns and the challenges endured in cloud robotics in section 4, the cloud robotics applications in section 5 and conclusion in section 6.

2. Cloud Robotics Architecture

The robotics that is networked is visualized as a state of transformation from the robots that are programmed to robot enabled with the clouds. The aim in developing the cloud robotics is to offload its highly complex computations to the cloud paradigm and minimizes the load forced over the each robot, This architecture mainly consists of two sections, or even can be split as two layers bottom layer and top layer , where the bottom layer holds different types of robots and the top layer is the cloud platform with its supporting components such as the proxy servers, massive spatial database, high-performance servers and other related components. The figure.2 below shows the general architecture of the cloud based robotics in an industrial environment [10].

Where the robot to robot communication is framed simply in the adhoc manner and the robot to cloud is framed in a centralized manner. The communications extended between the robots are carried out in a wireless medium forming a collaborative computing. This is initiated by developing pooled robots forming an adhoc cloud paradigm followed by the information transfer to the robots pooled. This causes even the robots that beyond the cloud access point to utilize the information's from the cloud. Further the infrastructures of the cloud are enables all the pooled robots to enjoy the resources of the cloud based on their demand.
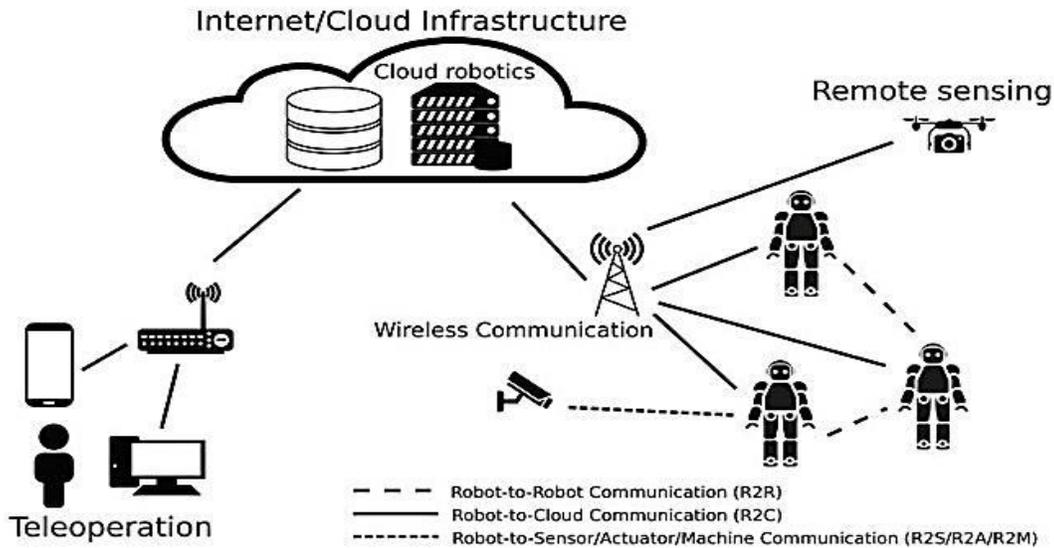
13

Figure.2 General Cloud Robotics in an Industrial Environment [10]

Thus allowing the clustered robots to offload computational- intensive tasks into the cloud platform for the execution to be carried out in a remote location developing robots with the "remote brain" the main advantages of the cloud based robotics architecture are, the robots are facilitated with the large volume of storage and equipped with the broad library skills that are required to perform the task.

3. The Enabling Forces of Cloud Robotics

The cloud robotics are enabled with the multiple of resources that are provided by the cloud networking and other technologies along with the communication protocols that are wireless. The section provides the detailed picture of the various enabling forces of cloud based robotics. The primary enabling force of cloud robotics is the cloud computing that has enhanced the rapidity of robots and the automated equipment's development. In paper [11] the SLAM utilizing the plat from of cloud was proposed to have qualitative results. Further the future cloud based robotics would concentrate more in analyzing the video, image, data mining and many other fields. The next enabling force is the big data providing a system that is automated by accessing huge resources from the infrastructure of the cloud limiting the challenges of the resources on board [12] the insights gained from the big data offers significant technical support that are essential in the development of the navigation achieved through the robots and as well as the system used in grasping. The next essential driving force is the open source, cooperative learning that is empowered by the learning

14

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Communication Technologies

techniques. They are the Reinforcement learning [13], Q-learning [14], hierarchical reinforcement learning, the learning techniques in the robotic network enhances the co-operative learning in the networked robotics enabling them to tackle challenging problems and importantly enhancing the accuracy in performing the tasks. The final enabling force is the network connectivity that is developed using the adhoc and the proactive routing methodologies [15]. The figure.3 below provides the routing protocol followed in the mobile robotic network [16].
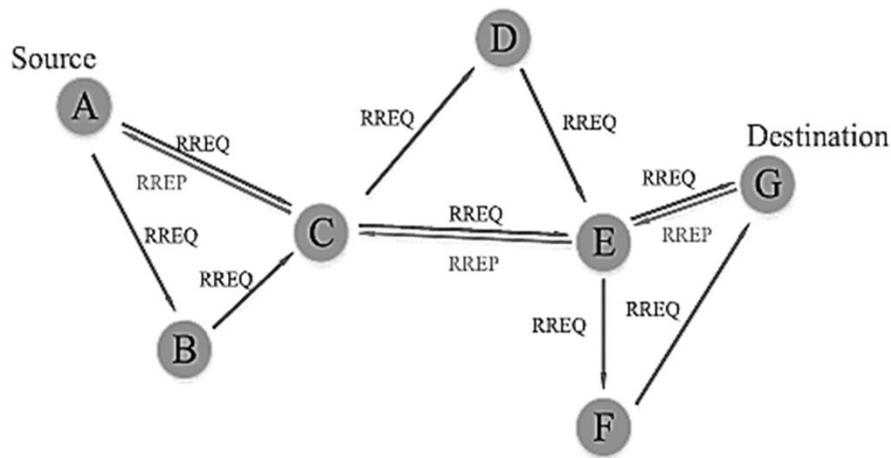

Figure.3 Classical Routing Protocol [16]

4. The Major Concerns and Challenges Endured In Cloud Robotics

This section provides the major concerns and the challenges endured in the cloud computing. The table.1 below provides the various challenges suffered by the cloud computing and its descriptions

Challenges	Description	Solutions
Resource Allocation And Scheduling [16] [17]	"As offloading the computational tasks to the cloud is a notable characteristics of the cloud" "Taking into consideration the different working equipment, interface settings, and network environments, for a given computational task, the choice of uploading, self-processing or assigning	"Developing protocols enabling careful selection of resources, offloading schemes, with the capability of managing delay incurred".

15

	the task to the nearest node has an important impact on overall performance". "Some of the challenges endured are delay, compatible resource allocation and carefully selection of offloading schemes."	
Data Interaction Between Robot And Cloud Platform [18]	"Faces challenges such as requirements of multiple interfaces equipped with various data formats, requires proper preprocessing , robustness , compatibility problems",	"The data interaction between the cloud and robotics could be improved employing the Software defined Networks".
Security In Cloud [19] [20] [21]	"These are hidden dangers affecting the devices used in computing and sensing, causing serious data leakages and loss of key data"	"Utilize authenticating schemes by incorporating the cryptographic techniques that are symmetric and Asymmetric"

Table.1 Summarizes the Challenges Endured and it's Solution

5. Cloud Robotics Applications

The cloud based robotics was mainly used in applications like SLAM "that are utilized in breaking the bottleneck caused by the limited onboard computing and the storage equipment" grasping system that are used in identifying the unknown objects and navigation presently the telerobotics [22] based on the cloud computing are employed in multiple of applications such as home automation, medical care, military purpose etc. The artificial integration in the cloud based robotics [23] would further enhance the performance of the system by improving the automation process, in terms of delay [24], processing speed [25] and access control.

6. Conclusion

The paper is a complete study on the cloud robotics, presenting the overview on the particulars of the architecture of the cloud robotics, the enabling forces of the cloud robotics, concerns and the challenges related to the cloud robotics and some of the applications associated with the cloud robotics. The paper highlights the different architectures of the robotic cloud computing, and presents the solution for the challenges endured by it. In future the paper aims in developing a cloud based robotics for the improving the primary health care services in the underdeveloped areas that mostly affected by epidemic disease.

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