

All about Cloud Robotics

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Abstract - The rise of the distributed computing, and the other cutting edge innovations has made conceivable the expansion of the processing and the information circulation skills of the advanced mechanics that are organized by fostering a cloud based automated design by using both the brought together and decentralized cloud that is deals with the machine to cloud and the machine to machine correspondence individually. The consolidation of the automated framework with the cloud makes plausible the planning of the savvy mechanical design that partakes in the upgraded effectiveness and an increased constant presentation. This cloud based advanced mechanics planned by mixture of advanced mechanics and the cloud advances engages the web empowered robots to get to the administrations of cloud on the fly. The paper is a review about the cloud based mechanical patterns and engineering, clarifying the powers that require the advanced mechanics converged with the cloud, its application and the central issues and the difficulties suffered in the mechanical technology that is incorporated with the cloud. The paper extensions to give a point by point study on the progressions impacted by the distributed computing over the modern robots likewise its future.

Keywords: Cloud robotics, mechanical patterns, mechanics, technology, computing.

I. Introduction

Cloud mechanical technology is a field of mechanical technology that endeavors to summon cloud advances, for example, distributed computing, distributed storage, and other Internet advances focused on the advantages of met framework and shared administrations for advanced mechanics.

Cloud Robot can be characterized as a framework that relies upon information or code from an organization to help its activity this definition focuses to future frameworks and many existing frameworks that incorporate arranged teleoperation or organized gatherings of versatile robots like automated elevated vehicles (UAVs) [1].

The term cloud Robotics were first presented by James kuffner In 2010 at Google his point was to acquaint another methodology with advanced mechanics that exploits the web as an asset for generally equal calculation and constant sharing of tremendous information assets [2], in other hand the accomplishment of cloud mechanical technology examination would help existing and future advanced mechanics applications to advance more as one of the standard assistance which depend on distributed computing. As per the past presentation we will focuses upon three terms to be specific distributed computing, advanced mechanics and cloud mechanical technology.

The cloud mechanical technology is an articulation comprises of two principle terms , the initial term is the cloud which is a model for empowering universal, advantageous and on-request network admittance to a common pool of configurable registering assets (for example networks, servers, stockpiling, applications, and administrations) that can be quickly provisioned and delivered with insignificant administration exertion or specialist organization association , the subsequent term is the mechanical technology which is known as a reprogrammable, multifunctional controller intended to move material, parts and apparatuses or specific gadgets through different modified movements for the exhibition of an assortment of assignments.

This paper comprises of following areas :- I Introduction, II :- writing study III :- Survey of Recent Trends in Cloud Robotics Architectures and Applications IV: issues V: Advantages VI: Cloud Computing and Robotics VII: Cloud Robotics System Architectures VIII : Cloud Robotics Applications IX: Open Issues, Challenges and Future Directions X: Cloud Robotics: Current Status and Open Issues XI : MAJOR DRIVING FORCES BEHIND THE DEVELOPMENT OF CLOUD ROBOTICS XII : APPLICATIONS OF CLOUD ROBOTICS XIII :Architecture and Challenges.

II. Literature Survey

Cloud mechanical technology is a field of advanced mechanics that endeavors to summon cloud innovations, for example, distributed computing, distributed storage, and other Internet advances focused on the advantages of merged

framework and shared administrations for advanced mechanics. When associated with the cloud, robots can profit from the strong calculation, stockpiling, and correspondence assets of current server farm in the cloud, which can process and share data from different robots or specialist (different machines, brilliant articles, people, and so forth) People can likewise designate undertakings to robots somewhat through networks. Distributed computing advancements empower robot frameworks to be blessed with strong capacity while diminishing expenses through cloud advances. Consequently, it is feasible to fabricate lightweight, minimal expense, more brilliant robots with a wise "cerebrum" in the cloud. The "cerebrum" comprises of server farm, information base, task organizers, profound learning, data handling, climate models, correspondence support, and so on.

III. Survey of Recent Trends in Cloud

Robotics Architectures and Applications

Mechanical technology has seen critical advancements over the previous many years bringing about its expanded applications to a few genuine issues including computerized fabricating, extra-earthly tasks, automated pursuit and salvage, catastrophe advanced mechanics, self-driving vehicles, socially assistive robots, and medical services and clinical robots. The robots utilized in a significant number of these applications are single robots that are restricted by their on-board equipment and computational requirements. To resolve this issue, the field of organized mechanical technology [1] arose very nearly twenty years prior, which associated a group of robots through a wired or remote correspondence organization.

IV. Issues

The principle issues related with organized robots happen because of asset limitations, data and learning requirements, and correspondence imperatives. The equipment imperatives of every individual robot restrict its registering and capacity limit bringing about an aggregate impediment of the organized robots. It is actually hard to change or overhaul the asset setups once a robot has been planned, constructed and sent. Organized robots are additionally compelled by data, as they approach just the data amassed by robots having a restricted assortment of sensors and associated through an organization. This can generally prompt execution gains in static conditions, however their presentation rapidly debases when the climate definitely changes or when they are set in new conditions. Arranged robots keep up with machine-to-machine correspondence utilizing correspondence conventions like proactive directing or impromptu steering which cause high calculation and memory necessities and high idleness. Complex genuine issues requiring continuous execution

request modern information investigation and computational abilities that are trying for arranged robots to deal.

V. Advantages

The expression "cloud mechanical technology" alludes to any robot or computerization framework that uses the cloud foundation for one or the other information or code for its execution, i.e., a framework where all detecting, calculation and memory are not coordinated into a solitary independent framework. Coordination of distributed computing into mechanical technology brings about a few benefits which are featured underneath:

Cloud advanced mechanics offers robots expanded computational power and extra room [4]. Cloud-empowered robots are not needed to perform convoluted assignments ready, however can offload calculation concentrated undertakings, for example, object acknowledgment, design coordinating, PC vision, and discourse combination and acknowledgment to the cloud. These assignments can be tackled a lot quicker on the cloud, progressively, using hugely equal calculation or matrix figuring abilities [4].

Alongside powerful offloading of computational assignments, cloud foundation in cloud mechanical technology Upholds versatile and on-request accessibility of computational assets [2].

Numerous applications in mechanical technology, as synchronous restriction and planning (SLAM) and other insight frameworks, quickly bring about gigantic measures of sensor information that is hard to store with the restricted locally available capacity limit on most robots. Cloud empowered robots approach high extra rooms presented by the cloud where they can store all the helpful data for usage in future [2].

Robots by data sharing on the most proficient method to tackle a convoluted assignment. Cloud advanced mechanics additionally permits robots to get to human information through publicly supporting using the cloud. Thus, with the presentation of cloud mechanical technology, robots are not generally independent frameworks restricted by their on-board abilities, yet they can use every one of the benefits presented by the cloud foundation.

VI. Cloud Computing and Robotics

Distributed computing can be casually characterized as a bunch of administrations that empower admittance to dispersed and shared figuring assets over the Internet, including data handling, data stockpiling and enormous datasets. There are a few business distributed computing

specialist co-ops at present like Amazon Web Services [66], Elastic Compute Cloud normally alluded as EC2 [67], Google Compute Engine [68] and Microsoft Azure [69]. Moving automated applications to the cloud requires exceptional structures or administration models that help this progress [3]. Distributed computing offers three sorts of administration models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). In the new past, Robot as a Service (RaaS) has been proposed as a distributed computing unit which works with the consistent mix of robot and installed gadgets into Web and distributed computing conditions.

VII. Cloud Robotics System Architectures

Among the prior works in cloud mechanical technology, the works by Arumugam et al., Mohanarajah et al. also Riazuelo et al. can be viewed as significant works which proposed and carried out the product design coordinating cloud administrations with mechanical technology equipment. DAVinCi is a product system which takes advantage of a few benefits of distributed computing for administration robots like adaptability and parallelism. The DAVinCi programming structure depends on the Hadoop bunch joined with the Robot Operating System (ROS) as the informing system for automated environments. The RoboEarth project is driven by an open-source cloud advanced mechanics stage called Rapyuta.

VIII. Cloud Robotics Applications

Cloud advanced mechanics applications can be grouped into the accompanying subcategories: insight and PC vision applications, route, getting a handle on or control, assembling or administration mechanical technology, social and clinical applications, publicly supporting and human-robot communication.

Discernment and Computer Vision Applications

There have been a few works over the previous years that use cloud-based answers for improving various parts of insight and item acknowledgment in automated frameworks. Beksi et al. [21] proposed a Cloud-based Object Recognition Engine (CORE) that can prepare for huge scope datasets, perform arrangement of 3D point cloud information and perform effective information move in an automated organization Center was experimentally assessed for full circle times during point cloud transmission utilizing User Datagram Protocol (UDP), Transmission Control Protocol (TCP) and Websocket convention, and UDP was found to give quickest full circle times however less unwavering quality contrasted with TCP and Websocket. It introduced the Cloud Robotics Visual Platform (CRVP) to improve robot vision.

Route

Many works in the new past have used the cloud for planning and confinement, which are two of the main errands for versatile robots. Planning alludes to the robot's course of seeing the climate with the assistance of its on-board sensors and making a guide of it, while limitation alludes to the robot's information about its overall situation in the apparent climate. The course of at the same time fabricating a guide and limiting a robot, prevalently known as SLAM, is a calculation escalated interaction, and large numbers of the new works have joined cloud advancements for quicker and more proficient execution of SLAM.

Getting a handle on or Manipulation

Control is a significant assignment in advanced mechanics, which has wide applications from homegrown help to robot-helped a medical procedure. Mechanical control represents specific difficulties, as it includes handle arranging in a high-layered space. A few works toward this path have incorporated the cloud foundation to outperform these difficulties. In [36], the creators proposed a cloud-based handle arranging system called Lightning, which empowers robots to design handles for control errands in high-layered spaces. Figure 6 presents the undeniable level compositional chart of the Lightning system. This system comprises of two modules running in equal in the cloud: a preparation without any preparation module and a module that recovers and adjusts ways put away in a library as and when required.

Production or Service Robotics

The development of cloud advanced mechanics has introduced another period of Smart Manufacturing Environments (SME) in industry where independent robots outfitted with cloud assets are sent in certifiable modern undertakings like distribution center administration, robotized pressing, and so on. A few works in the new past have glanced thusly. Cardarelli et al. [47] proposed a unified cloud administration liable for getting and combining information obtained by various detecting frameworks.

This information are then disseminated to independent vehicles, which use these for executing progressed route methodologies in genuine modern climate settings. The framework was approved in a truly modern climate to securely perform snag aversion with an independently determined forklift. Singhal et al. [49] talk about a point by point execution of a cloud-based framework for dealing with an armada of independent portable robots working in a production line or stockroom climate.

Social, Agriculture, Medical and Disaster Robotics

Inferable from its solid computational and capacity benefits, cloud advanced mechanics has tracked down its applications in various genuine issues Bhargava et al. Proposed a portable cloud synergistic methodology for setting mindful outside route that uses the computational force of assets made available by distributed computing suppliers for constant picture handling. The creators additionally fostered an open air route application with incorporated help for person on foot crossing direction that is accepted to be useful for safe open air route particularly for the visually impaired and outwardly hindered in new conditions.

Publicly supporting and Human–Robot Interaction

Distributed computing certifies publicly supporting and works with human–robot connection for proficiently settling mechanical missions. The Human–Robot Cloud (HRC) [63] expanded distributed computing by investigating two significant bearings. In the first place, it advanced the use of disseminated detecting and actuator organizations, subsequently stretching out distributed computing to the actual world. Besides, notwithstanding electronic parts, HRC additionally incorporates the human physical and intellectual parts and consequently gives publicly supporting to the cloud as brief, non-master association with the cloud.

IX. Open Issues and Future Directions

Effective Resource and Task Allocation over the Cloud. One of the vital determinants of execution of cloud-based automated frameworks is settling on a choice to transfer an undertaking to the cloud as opposed to handling it utilizing nearby assets. Late works have proposed practical dexterity instruments including barbers [100], consecutive games [101] and conviction engendering methods [102] for continuous asset assignment and recovery in cloud-based portable automated frameworks. Be that as it may, the exhibition of these procedures is powerless to the unique changes in the organization geography just as postponements during the coordination cycle. An issue deserving of future exploration is to empower asset distribution techniques in the cloud to nimbly deal with dynamic changes in the organization that may happen during the asset portion process.

Decreasing Communication Delays over the Cloud. Cloud-robot correspondence normally connected with cloud mechanical frameworks can bring about significant postponements. The enormous measures of information that typically emerge in numerous mechanical technology applications like discernment, SLAM and route bother correspondence delays. Truth be told, the focal issue in cloud mechanical technology is the calculation correspondence defer

that perseveres among robots and the cloud for a large portion of the applications. Over ongoing years, remote innovation has made consistent upgrades, yet delays are hard to stay away from within the sight of organization association issues between the robot and the cloud administrations. To conquer this limit, novel burden appropriation calculations with inborn, whenever attributes should be planned so when a calculation demand from a robot can't be transferred as expected to the cloud, reinforcement systems are accessible to progressively apportion the errand and limit the robot's defer time in performing activities.

X. Cloud Robotics: Current Status and Open Issues

A mechanical organization alludes to a gathering of robots associated through a wired or remote correspondence organization. A singular robot in organized advanced mechanics is viewed as a hub. With detecting information and data divided between hubs, the administrators can send order information from a distance and get estimation criticism, consequently guaranteeing that a particular activity is completed.

With the advancement of distributed computing, huge information [3] and other arising innovations [4], [5], the joining of cloud innovation and multi-robot frameworks takes into consideration the plan of multi-robot frameworks with elite execution and high intricacy.

XI. Major Driving Forces behind the Development of Cloud Robotics

Cloud automated frameworks' construction includes various cloud, Organizing and implanted frameworks' advancements, just as a wide range of remote correspondence conventions. In this segment, we basically talk about four significant main impetuses: distributed computing, large information, open source, robot agreeable learning, and organization availability.

Distributed computing for Robotics

As we probably are aware, distributed computing which is appropriate for examining based examinations, has been generally utilized in enormous scope equal figuring applications with extraordinary achievement. For instance, Ref. [20] proposed an original design which consolidates versatile distributed computing and vehicular digital physical systems. In the advanced mechanics field, because of the great registering execution of cloud-based frameworks, when the processing task is transferred to the cloud, the computational heap of figuring gear is decreased generally. For instance, getting a handle on dependent on distributed computing for obscure article shapes has accomplished extraordinary vigor.

In the field of multi-robot tasks, distributed computing has incredibly sped up the speed of improvement of mechanical and computerization gear.

Open Source for Robotics

With the improvement of cloud innovation, the soul of open source is invading into the cloud advanced mechanics field. Among them, the most delegate is ROS and RoboEarth.

ROS is a notable structure, whose open source permit permits the improvement of the code reuse rate and advancement effectiveness of this robot working framework. There are two significant parts to ROS: framework upkeep and dissemination..

Primary: This is the center part, planned at the Willow Garage research lab in a joint effort with other devel-opers, which gives upkeep. It gives a portion of the fundamental devices for appropriated processing, just as the whole ROS of the center piece of the program.

Universe: the worldwide extent of the code, kept up with by the global ROS people group association. It incorporates libraries of code written in a few programming dialects, such as OpenCV and PCL. As a general rule, the Universe contains calculations, structures and equipment drivers.

Robot Cooperative Learning

A multi-robot framework is a central field of mechanical technology. With the help of different robots in a group, a multi-robot framework can streamline the singular inadequacies and fundamentally work on the complete precision and intricacy of assignments. Cooperating learning, quite possibly the main topic in multi-robot frameworks, actually faces a great deal of testing issues.

Network Connectivity

Network creates with multi-robot framework also. Past analysts have enormously added to this issue [26]. Conventional entomb correspondence inside mechanical technology is a regular Machine to Machine (M2M) correspondence design. Collective learning necessitates that the worldwide errand need is more noteworthy than the need of the hub undertaking, and this applies to dynamic bundle communication and control too. These imperatives bring about higher prerequisites on the control calculation.

Average Applications of Cloud Robotics

With the approach of industry 4.0 [30], [31], the introduction of digital actual frameworks [32], [33] and cloud technologies makes it conceivable to altogether work on

automated execution. Lately, the investigation of cloud advanced mechanics has accomplished quick improvement through the help of significant cloud advances. Table 1 shows the fundamental work in this area. In this part, we will present some exemplary utilizations of the cloud mechanical technology, including SLAM, getting a handle on and route.

Main Points of Interest and Challenges

This part centers on main points of contention and difficulties in cloud mechanical technology. The collective learning referenced before is in reality just one of the parts of figuring asset allotment and booking. As per the constant necessities of various situations, setting up a harmony between continuous requests and handling execution is a center issue of asset allotment and planning. Distributed storage implies the far off capacity of information. Regardless of whether it is business protection or logical examination, the significance of information likewise forces further prerequisites on cloud security. Automated cloud plat-structures need to associate utilizing this information, which implies that the information to be investigated should be transferred in a specific arrangement. Moreover, handled data additionally should be gotten back from the cloud stage to the robot in a specific structure. At long last, the presentation of administration quality affirmation frameworks and impacts' investigation, to keep up with the organization stream for a given transmission capacity upgrades constant execution and computational productivity.

Cloud Security

The presentation of cloud innovation has significantly extended the intricacy of multi-robot tasks. Simultaneously, it additionally presented new specialized difficulties: the protection and security issues brought by the cloud innovation. These secret risks likewise influence information produced by registering gadgets and sensors utilized in cloud mechanical technology. Business science and innovation arrangements have experienced genuine information spillage occurrences, particularly during the transfer of photographs and video to the cloud [64]. In logical exploration and modern practice, key information put away in the cloud might be a long way from the programmer to take, prompting the deficiency of key information.

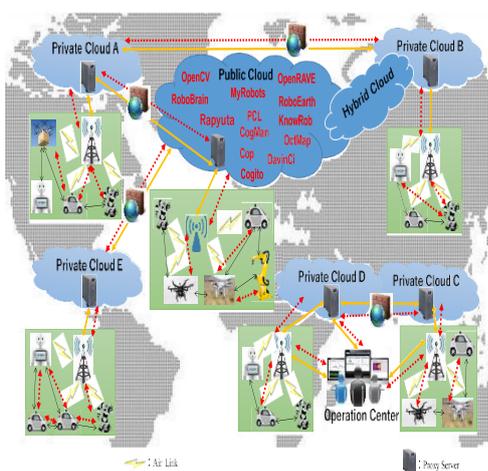
XII. Applications of Cloud Robotics

Cloud Robotic is an intriguing exploration theme, yet it needs to distinguish its objective applications and tracks down its specific areas it is accepted that CR is a method for bringing cognizance into the area of advanced mechanics, which is imagined and emphatically upheld by the European Union through the FP calls. A potential region where CR

might seem is of home robots, based on the flimsy customer model where the gadgets utilize the cloud framework for appropriated processing and storage. Also to show the utilizations of cloud mechanical technology the analyses planned on the Google Object Recognition Engine and the PR2 robot have been directed appearance the significant of cloud mechanical technology in the field of article acknowledgment [24], yet the most encouraging application spaces of administration advanced mechanics are medical services and homecare this was found by notice different new frameworks that have arisen, supporting insignificantly obtrusive tele medical procedure or tele presence robots going about as a distant specialist for a meeting specialist. In any case, because of the criticality of the assignments (on account of any unfriendly occasions) clinical applications are hesitant to trust task-calculation on the cloud. Nevertheless, homecare is a substantially more encouraging application, where a considerable lot of the everyday undertakings of the maturing individuals ought to be taken over by robots.

XIII. Architecture and Challenges

Robots in such a mechanical organization could impart their insight and calculation responsibilities to different robots in a similar organization; the general viability of the automated organization is as yet restricted to extra room, the handling power, also number and kind of sensors and camera in the actual robots. That is, the mechanical participation in such an automated organization is confined by the intrinsic actual constraints of the aggregate calculation and information sharing limit of the calculation and capacity assets of the automated organization To defeat the restrictions of basic arranged advanced mechanics, cloud mechanical technology, which use arising distributed computing advances to stretch out organized advanced mechanics to incorporate the flexible assets of a distributed computing foundation, is currently broadly acknowledged as a promising way to deal with further develop effectiveness in organized advanced mechanics.



Cloud Robotics Cooperation Architecture

Fig. 1 represents a nonexclusive design for cloud mechanical technology, including a bunch of robot groups and a bunch of foundation based mists. A robot bunch is shaped by a powerful arrangement of adjoining robots that work helpfully to achieve complex undertakings. As a robot moves starting with one climate then onto the next, it can consistently join an alternate bunch of robots can in any case profit from cloud assets. A robot can speak with its companions utilizing messages communicated over an impromptu remote organization by means of a nearby remote organization.

Applications

Later the Great East Japan tremor debacle, we began a cloud-mechanical participation project supported by the Fukushima prefecture. The undertaking means to construct a cloud-automated participation framework to help future calamity the executives, and the difficult destruction task at the Fukushima Daiichi NPP.

In our cloud-automated participation framework, a robot can call for help from other adjoining robots in the organization. The robot can send its route heading, accurate GPS area, and other applicable data (like a strange snag in the way or a valuable diversion).

Challenges

QoS Issues

The QoS for mechanical collaboration in cloud mechanical technology alludes to its presentation in fulfilling its clients' inclinations. Specifically, two QoS factors, in particular dormancy and energy utilization, are talked about underneath.

A. Latency Issues

In cloud mechanical technology, inertness is characterized as the time engaged with obtaining the fundamental information or offloading the computational errands and recovering the outcomes from the cloud. It includes many variables, like handling time on individual robots, + handling time in the cloud, the info/yield information sizes, information transport time, and organization inactivity. From one perspective, to diminish inactivity, an undertaking application should know about the assignment's calculation time on both the robot side and the cloud side for dormancy assessment. The test here is that assessing the calculation season of undertaking parts in an application is an intricate issue. Cloud mechanical technology needs to gather and dissect information continuously and settle on speedy choices. Such frameworks are delicate to inertness However, security and trust matters are the main elements hampering the proposed arrangement.

B. Energy Efficiency Issues

Battery is perhaps the most valuable asset for versatile robot. The key of energy-productivity cloud mechanical technology is to look for better tradeoff between the transmission energy utilization and calculation energy utilization. To make automated applications energy effective, the applications should know about how much energy needed for calculation offloading to the remote cloud and robot-based application execution.

C. Protection and security

Protection and Security in Cloud-Robot Systems. The expanded use of cloud-based mechanical technology advancements presents protection and security issues. Cloud-based administrations include mechanical information to be put away and cycles to be performed somewhat in the cloud, making these applications defenseless against programmers and noxious clients. Distant capacity of information in the cloud can prompt unseemly access, control and erasure of important information by programmers. Far off execution of mechanical administrations in the cloud makes it more straightforward for programmers to get to and adjust these administrations, hence changing the conduct of robot assignments in noxious ways. In such manner, analysts have utilized the term crypto mechanical technology as a unification of network safety and mechanical technology.

Correspondence Issues

Cloud advanced mechanics ought to guarantee that there is quick and continuous Internet availability among robots and the remote cloud. The singular robots are constantly connected to the remote cloud from any appropriate setting for task execution [58]. In any case, when contrasted and wired organizations, remote organizations are described by discontinuous, low-transfer speed, and less-dependable transmission.

The figure 1 underneath shows the three methodologies of cloud mechanical technology.

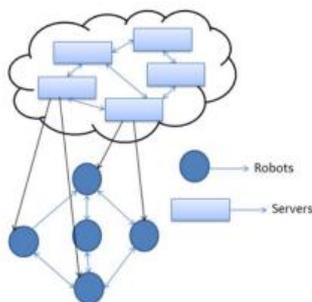


Figure 1: (a) Peer based Frame Work for Computation

In Figure 1(a) Peer based Frame Work for Computation the mechanical organization are straightforwardly associated with the cloud worldview and furnishes a moderate strength and interoperability with the high versatility.

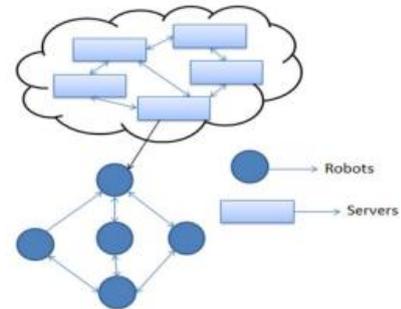


Figure 1 (b): Proxy based Frame Work for Computation

In Figure 1(b) Proxy based casing work "the VM unit and the Robotic organization in the cloud worldview aces and keeps up with the extension in getting and disseminating the assignment in the shared way" furnishing a lower level of strength with high interoperability and medium portability.

Figure 2 General Cloud Robotics in an Industrial Environment.

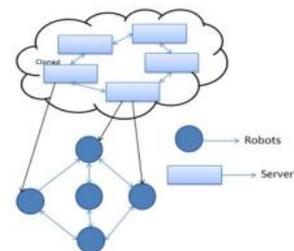


Figure 1 (c): Clone based Frame Work for Computation

Though in Figure 1(c) Clone based edge work for calculation "where every single robot has a duplicate or clone in the cloud and the positions are allocated to the robot itself or to its clone". The clone based gives an uplifted strength the low interoperability and low versatility. Each computational engineering has its own benefits and negative marks in the differing situations, "The models are constantly executed relying upon the framework asset accessibility, application prerequisites and condition of organizations based on how much the responsibility".

The Major Concerns and Challenges Endured In Cloud Robotics

This segment gives the central issues and the difficulties suffered in the distributed computing. The table.1 underneath gives the different difficulties endured by the distributed computing and its portrayal

Cloud Robotics Applications

The cloud based advanced mechanics was mostly utilized in applications like SLAM "that are used in breaking the bottleneck brought about by the restricted locally available figuring and the capacity hardware" getting a handle on framework that are utilized in distinguishing the obscure items and route by and by the tele robotics dependent on the distributed computing are utilized in different of utilizations, for example, home computerization, clinical consideration, military reason and so on The counterfeit joining in the cloud based advanced mechanics would additionally upgrade the presentation of the framework by further developing the computerization cycle, as far as postponement , handling speed What's more access control.

XIV. Conclusion

The paper is a complete study on the cloud robotics, presenting the overview on the particulars of the architecture of the cloud robotics, their advantages, disadvantages, future scope and the applications associated with the cloud robotics. The paper highlights the different architectures of the robotic cloud computing, current status of cloud robotics and its open issues.

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