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Robotic Services In Cloud Computing

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Abstract:

Cloud computing and service oriented architecture (SOA) are the dominant computing paradigm. Since past few years Robotics applications have also started to build around these paradigms. This paper presents entrance of robotic services in SOA and cloud computing. Where a client/user can opt for the robotic services present at the cloud like navigation, map building, object recognition etc. Map-reduce computing cluster is also facilitated at the cloud to process large amount of data for the cloud robotic services. The whole system follows the Web 2.0 standard. We also reported the simulation results for service based speech controlled robots with visual programming language (VPL) of Microsoft Development Robotics Studio (MDRS) and implementation of map-reduce computing cluster in robotic cloud.

Keywords: *Cloud Computing, Robotic Services, Robot as a Service, Cloud Robotics, Cloud Robots.*

1. INTRODUCTION

Cloud enabled robots are considered as one of the active developing research field across various researchers. This can extends the functionality of robots and one can think to deploy them in unstructured environment. One can visualize the usefulness of cloud architecture due to its leveraged capability over "in-house" resources [1]. This can handle computational intensive tasks like navigation, map building, path planning, localization, object recognition etc.; it can also provide some useful instant information [2]. Consequently, the significant power consumption in mobile robots can be lower down. Generally, a physical robot is limited by power supply, size & shape, computational power, memory, working environment and locomotion mode. However, the load of computation and memory can be shared by networked robots but still the overall effectiveness is limited by the size of robotic network, and also it doesn't make any note on stand-alone robots [3]. The infrastructure of existing and rapidly evolving network and web technology enables rapid improvements in terms of performance and accessibility. Cloud enabled robots open the doors for many applications such as [4]:

- Virtualization over physical robots.
- Access to the web facilities can be given to the robots.
- Reducing the cost of robotics hardware.
- Makes cheaper, lighter and "smarter" robots.
- Can have functionalities like object recognition and voice services on demand.
- A "shared knowledge base" can be created for robots.
- Outcomes/learned skills can all be published or shared among the robots.
- A test-bed can be created to carry out the research by enabling Robots as a service.

Service Oriented Architecture (SOA), Cloud computing, Map-reduce computing cluster and Microsoft Robotics Developer Studio (MRDS) tool, which is a mobile robot rapid prototyping tool, is used to define our overall system.

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A. Service Oriented Architecture

SOA is an inherent part of Cloud computing paradigm, and it is a very popular service delivery model among many IT companies across the globe. The loosely coupled policy of SOA enables communication among various services through standard message exchanging protocol [5]. SOA also has some other noticeable properties like services are independent to the interface; services can be added or removed anytime; a service is considered as a self-contained unit [6].

B. Cloud computing

Cloud computing paradigm enables desktop-based computing to move towards full web-based computing where a web browser can be used to access, develop and configure various applications, hardware and data over web [7]. Generally, cloud computing offers three types of service delivery models namely Software as a Service (SaaS), Platform as a Service (SaaS) and Infrastructure as a Service (SaaS). One can introduce 'X' as a service by following cloud computing standards like web 2.0, Data as a Service (DaaS) and Hardware as a Service (HaaS) are some of such examples.

C. Map-reduce computing cluster

Hadoop Map-reduce is a programming model designed to run data intensive distributed applications parallelly [8]. Hadoop Map-reduce is an open source implementation of Map-reduce programming model and distributed file system. It is totally written in Java programming language. The basic idea behind it, was to provide high throughput of data computation; it can also be utilized for distributed storage. This can decrease computing time of an application significantly by using hundreds of computing units. Estimating the diameter of big graphs and machine translation for large set of data are some of the problem which has been successfully solved using hadoop distributed computing [9].
A special file system called as Hadoop Distributed File System (HDFS) was created from Google File System (GFS) and

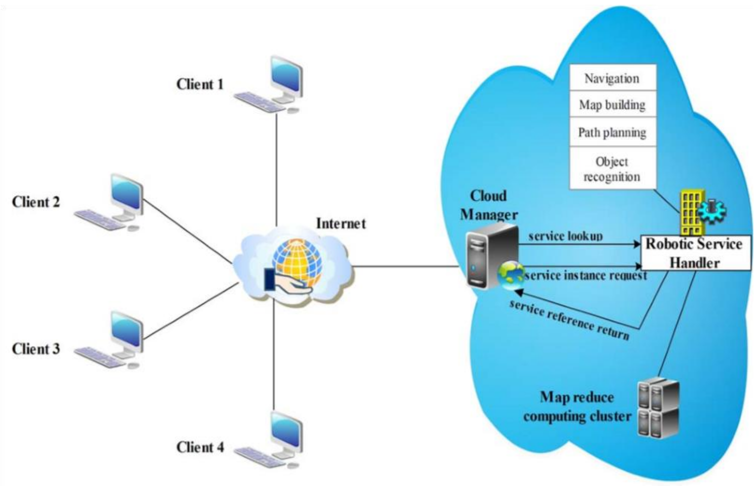


Figure. 1 Robotic service cloud

Google Map-reduce [10].This initiative resulted in a powerful but yet a simple interface. It enables automatic distribution of large computations irrespective of their size and place on commodity of computing units and provides parallelization in same fashion.

D. Microsoft Robotics Developer Studio

Microsoft Robotics Developer Studio (MRDS) is a fully integrated robotic software package specially designed for robot control and simulation [11]. It is based on windows environment. MRDS uses CCR (Concurrency ad Coordination Runtime) which manages asynchronous parallel tasks and DSS (Decentralized Software Services) to achieve complex behaviours. It provides programming supports in C#, VB and VPL. MRDS has also applied SOA into embedded system. The main feature of MRDS is to separate virtual services from physical devices through manifest (a mapping layer). It also includes facilities for:

- Design of Software modules.
- Communication protocols.
- Mechanism for process monitoring.
- Simulation environment.
- Distribution of systems across multiple hosts.
- Rapid prototyping.
- Significant number of standard components for basic programming, control, input/output and interface.

In this paper, we use SOA and Cloud computing architecture to lay the foundation for offering robotic services. On the other hand, map-reduce computing cluster can help the system so that computational task on large data set can be performed quickly.

2. PROPOSED FRAMEWORK

We present an approach for the situations like, when a user want to access robotic services to test their data; implement some algorithms; to take results from robotic Hardware or Software; to provide virtualization of robots; to prepare a common platform for working on robots.

Fig.1 shows a detailed description of our system. In this cloud, there are three main components namely cloud manager, robotic service handler and Map-reduce computing cluster. In this system when Client/User wants to use any robotic service, it interacts with cloud via internet over http/https. Cloud manager maintains incoming service requests; it checks the authorization of requesting client. Once the client is authorized requested service is checked at the robotic service handler. If the service is available then it is allotted to the client otherwise request is put into the service request buffer.

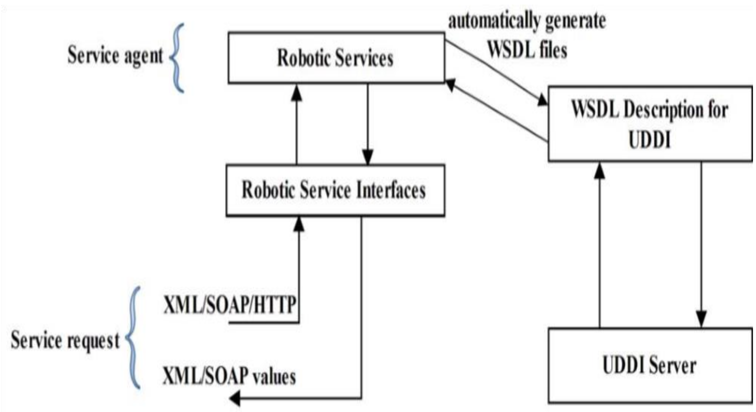


Figure 2. Flow of SOA in robotic service cloud

Fig.2 shows the detailed working flow of robotic services in the proposed system. Where, WSDL is used to define signature of robotic services and robotic services are maintained by UDDI server. A service is requested by wrapping the input arguments into XML and sent over HTTP using SOAP to robotic service interface. Robotic interface checks the authentication, compatibility and availability of service and subsequently passed to service agent, which in turn execute service. At the end, the result is passed to the service requester via robotic service interface. Robotic service handler contains the robotic services like navigation, path planning, map building, object recognition etc. It takes the help of map-reduce computing cluster to process large amount of data. Services at robotic service handler are independent and one can add or remove service to it.

Map-reduce computing cluster uses map-reduce programming model to process data. It implements two functions namely map and reduce that takes input pair k1, v1 and produces new pair of key/value pair k2, v2. All same key values are sent to a single reduce function and reduce function accept the vice versa and merges these values down to a smaller value/output. Generally, data is split into 16-64 MB blocks.

3. RESULTS AND SIMULATION

Visual Programming Language (VPL) of MRDS [12] [13] is used to validate our concept. VPL is a graphical data-flow based programming language model based on event driven and data driven approach. This supports advanced programming, code development and rapid prototyping of robotic services and other applications.

Fig.3 shows the prototyping model of the created speech controller robot service. We used Create robot from iRobot

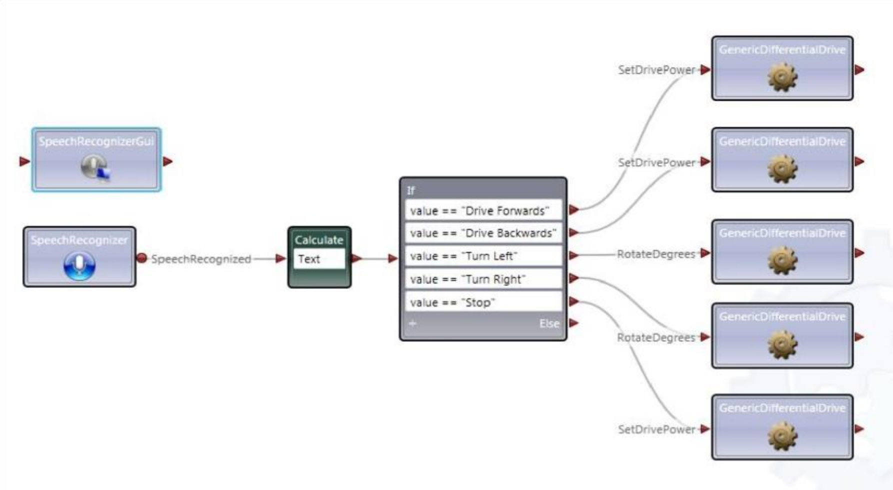


Figure 3. Prototyping simulation of speech controlled robotic service in VPL

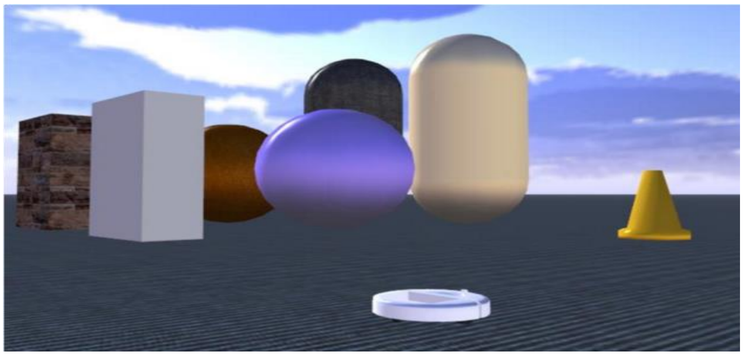
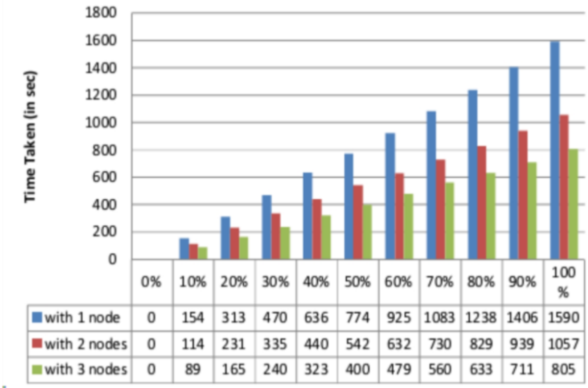


Figure 4. Navigation of Create robot through speech

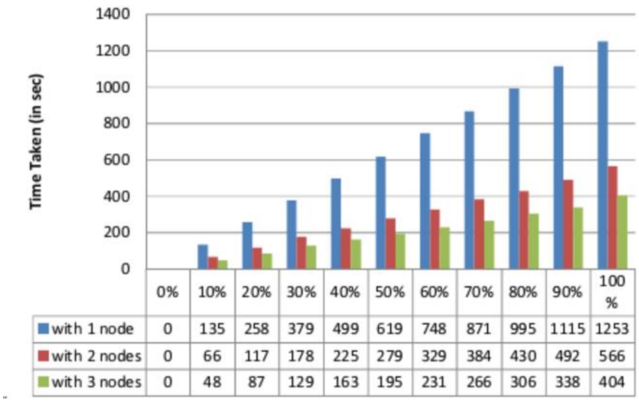
[14] to make a command operated robot through robotic services; it is basically a variation of Roomba robot. This robot is well suited for both in simulation and in hardware. *SpeechRecognizer* and

GenericDifferentialDrive VPL services are used to equip a robot with speech and drive capability. Variables like SET DRIVE POWER and ROTATE DEGREES are set for speed and rotation of robot[15]. Whereas, the variable status indicates the direction of robot navigation; it contains the values like "Drive Forwards", "Drive Backwards", "Drive Left", "Drive Right" and "Stop". Fig.4 shows the real time navigation of Create robot in MRDS simulation where the robot is surrounded by artificially created obstacles and the robot is being controlled through speech. Moreover, efforts are being done to control it through web interface.



	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100 %
with 1 node	0	154	313	470	636	774	925	1083	1238	1406	1590
with 2 nodes	0	114	231	335	440	542	632	730	829	939	1057
with 3 nodes	0	89	165	240	323	400	479	560	633	711	805

Figure 5. Performance on 500MB data



	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100 %
with 1 node	0	135	258	379	499	619	748	871	995	1115	1253
with 2 nodes	0	66	117	178	225	279	329	384	430	492	566
with 3 nodes	0	48	87	129	163	195	231	266	306	338	404

Figure 6. Performance on 1GB data

We have taken some data in the form of images from different robots to test the validity of computing cluster in our robotic service cloud. The size of the data is carried 500MB and 1GB respectively with one, two and three computing nodes cluster that uses map-reduce algorithm to process the data as shown in Fig 5 and 6. The performance graph clearly indicates the usefulness of map-reduce computing cluster which makes computation faster depending upon the size of the cluster. In the graphs, time (in seconds) taken by different size of cluster is shown and it depends upon the computational power of individual unit present in the cluster [16]. Hence, the performance will vary when experimenting on different hardware configuration.

CONCLUSION AND FUTURE WORK

In this paper, we have shown an approach to introduce robotic services in cloud. At this cloud a client can have services like navigation, map building, object recognition etc. Moreover, a rapidly executed service can be obtained with the use of map-reduce computing cluster. The services are provided with the use of visual programming language of MRDS. And some results of map-reduce computing cluster are also presented. The whole system is tested successfully for speech based navigation using Create robot. In this work, we have enlisted only few services whereas; more number of services can be added to improve functionality of the overall system. Furthermore, we have to include support for other robots with different structured/unstructured working environment. But, this work opens the scope for virtualization of robots by offering different robotic services and a test-bed for testing robotic algorithms.

REFERENCES

[1] J. Tao, H. Marten, D. Kramer, and W. Karl, "An intuitive framework for accessing computing clouds," *Procedia CS*, vol. 4, pp. 2049–2057, 2011.

[2] R. Doriya, P. Chakraborty, and G. C. Nandi, "'robot-cloud': A framework to assist heterogeneous low cost robots," in *International Conference on Communication, Information and Computing Technologies (ICCICT-2012)*, October 2012, pp. 1–5.

[3] G. Hu, W. P. Tay, and Y. Wen, "Cloud robotics: architecture, challenges and applications," *Network, IEEE*, vol. 26, no. 3, pp. 21 –28, may-june 2012.

[4] J. Kuffner(Google), ""what's next" - cloud-enabled humanoid robots," in *Humanoids2010 Workshop*, 2010.

[5] Y. Chen, "Service-oriented computing in recomposable embedded systems," february 2006.

[6] M. Huhns and M. Singh, "Service-oriented computing: key concepts and principles," *Internet Computing, IEEE*, vol. 9, no. 1, pp. 75 – 81, jan-feb 2005.

[7] M. Armbrust, A. Fox, R. Griffith, A. D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, and M. Zaharia, "A view of cloud computing," *Commun. ACM*, vol. 53, no. 4, pp. 50–58, Apr.
2010. [Online]. Available: http://doi.acm.org/10.1145/1721654.1721672 [8] (Last accessed: 2012, October)

[9] U. Kang, C. Tsourakakis, A. P. Appel, C. Faloutsos, and J. Leskovec, "Hadi: Fast diameter estimation and mining in massive graphs with hadoop," *Technical report*, School of Computer Science, Carnegie Mellon University Pittsburgh, december 2008.

[10] (Last accessed: 2012, October) http://www.kheafield.com [online].

[11] H. I. Christensen, "Introduction to robotics developer studio (rds)."

[12] M. Corporation, "Microsoft robotics developer studio," October 2012, http://www.microsoft.com/Robotics/ [online].

[13] W. T. Tsai, Q. Huang, and X. Sun, "A collaborative service-oriented simulation framework with microsoft robotic studio," in *Proceedings of the 41st Annual Simulation Symposium (anss-41 2008)*, ser. ANSS-41 '08. Washington, DC, USA: IEEE Computer Society, 2008, pp. 263– 270.

[14] M. Corporation, "irobot create and roomba," October 2012, http://msdn.microsoft.com/en-us/library/bb483025.aspx [online].

[15] SS J. Durga Prasad Rao, Thakur Devraj Singh, Online Voting System For India Based, Printing Area International Research Journal 2 (42), 098-0104.

[16] AD J. Durga Prasad Rao, Madhuri Verma, Online campus Recruitment System ,Printing Area International Research Journal 2 (42), 89-92.

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