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Service-Oriented Multi-Agent Data Intensive Architecture for Biomedical Cloud

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Abstract

Cloud Computing brings out a modern approach which allows us to develop dynamic, distributed and highly scalable software. It provides services and computing through the networks. Service-Oriented Architecture (SOA) and agent frameworks furnishes tools for developing distributed and multi-agent systems which can be used for the administration of cloud computing environments which supports the above characteristics. This paper presents a SOQM (Service-Oriented Qos-Assured and Multi-Agent Cloud Computing) architecture which includes physical device and virtual resource layer, cloud service provision layer, cloud service management and multi-agent layer to support QoS assured cloud service provision and request. SOQM has been applied to the analysis of biomedical data and has allowed the efficient management of the allocation of resources to the different system agents. It has proposed a finite multi server model where the virtual machines are provisioned depending on the customers in the system.

Keywords: Cloud Computing, SOA, Biomedical Data, QoS, Multi-agent Architecture

1. INTRODUCTION

Cloud computing is a new commercial infrastructure epitome. This new technology is used for providing shared information and communication technology services. The technology of virtualization and resource sharing from a pool of resources provides a variety of worthy properties. A huge number of clients with different necessities are served by clouds having a single set of physical resources. Thus, through geographically dispersed data centers clouds have the inherent capacity to furnish their owners the profits of scaling the hardware resources supporting a system with demand as well as rendering high availability. Cloud computing implicates a service-oriented architecture (SOA), reducing information technology overhead for the end-users. The new technology provides greater flexibility to the customers by cutting down the total cost of ownership by providing on demand services (Vouk, 2008).

Distributed computing, parallel computing and grid computing has contributed platform virtualization(Buyya et al., 2008) technology into the arena of high performance computing which is the primary evolution panorama of cloud computing. Through virtualization the system achieves flexibility, user isolation and security through custom user images. Because of the commercial need, a cloud provider normally has a proprietary where a custom user image runs only on the provider's site. Cloud computing adopts most of the cross-site technologies applied to grid computing. Comparing to the traditional computing epitomes cloud computing is scalable, it can be encapsulated as an abstract entity, and the services are dynamically configurable. Cloud Computing infrastructure allows users to achieve more efficient use of their IT hardware and software investments with super-user privileges on-demand. This is accomplished by analyzing the physical barrier inherent in isolated systems, automating the management of the group of the systems as a single entity.

The image analysis, protein folding, data mining and gene sequencing are the important tools for biomedical applications and researchers. These resource-intensive shared applications often involve large data sets, catalogs, and archives, under multiple owners, often with bursty

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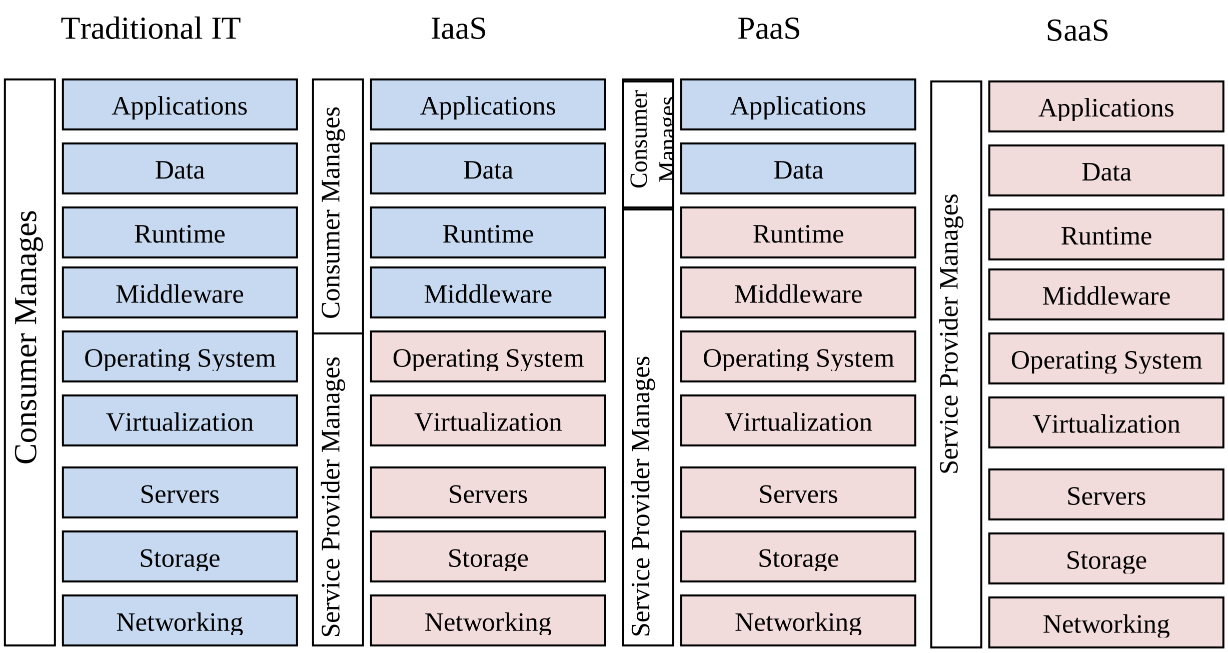
Figure 1. Behavior of Cloud Computing Service Models (Buyya et al., 2008)



workloads. The biomedical association (often involving multiple institutions) has implemented their applications in distributed grid architecture on laboratory-hosted servers. To affirm such servers, laboratories require space, cooling, power as well as low-level system administration, negotiations, firewalls between institutions. Clouds shift the responsibility to install and maintain hardware and basic computational services away from the biomedical consortium to the cloud vendor.

QoS is the standard which measures the expiation of cloud users using the cloud computing services. Cloud computing delivers three kinds of services: Infrastructure as a service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) (Foster et al., 2004, Rimal et al., 2009). Figure 1 gives a graphical representation of the different service models, and their components. These services are available to users in a Pay per-use-on-demand model.

The paper is structured as follows. Section 2 presents the biomedical computing. In Section 3, we discuss the service-oriented multi-agent cloud computing architecture. The performance measures and waiting time analysis is carried out in this section. The numerical results to demonstrate the effectiveness of the proposed model are presented. Section 4 concludes the paper.

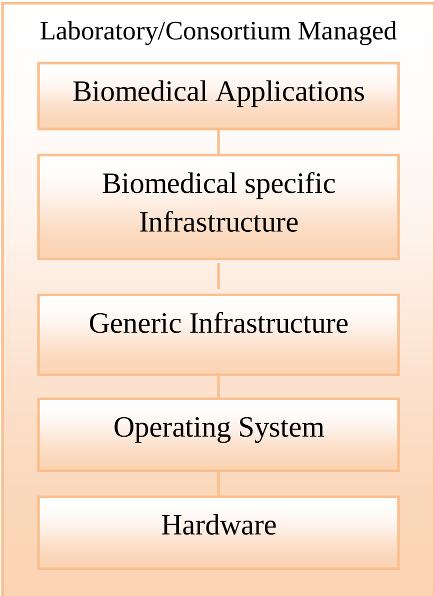
2. BIO MEDICAL COMPUTING

In biomedical computing clouds have an important role such as to compute services, archival storage. Individual labs often include basic servers. Labs that engage in computationally expensive research (e.g., protein folding or simulations) may rely on clusters of high-performance machines with fast interconnect between processors. At the other extreme, international repositories (e.g., SwissProt and GenBank) require extensive storage, but less impressive computational power. Between these extremes are biomedical consortia that facilitate the exchange of data and applications among its participants. In this section, we provide an overview of biomedical computing infrastructure, paying particular attention to the needs of consortia.

2.1. Laboratory Infrastructure

To meet the service and research needs, a laboratory must build or acquire computational infrastructure. As illustrated in Figure 2, the most canonic capabilities include computation, storage, and network bandwidth. The laboratory or the laboratory consortium manages the operating system, generic infrastructure (such as a database management system–DBMS, catalog, digital library, or workflow manager) and complex policies. Uniquely biomedical infrastructure (e.g., BLAST) leverages this generic infrastructure. Finally, biomedical applications are deployed atop the underlying layers.

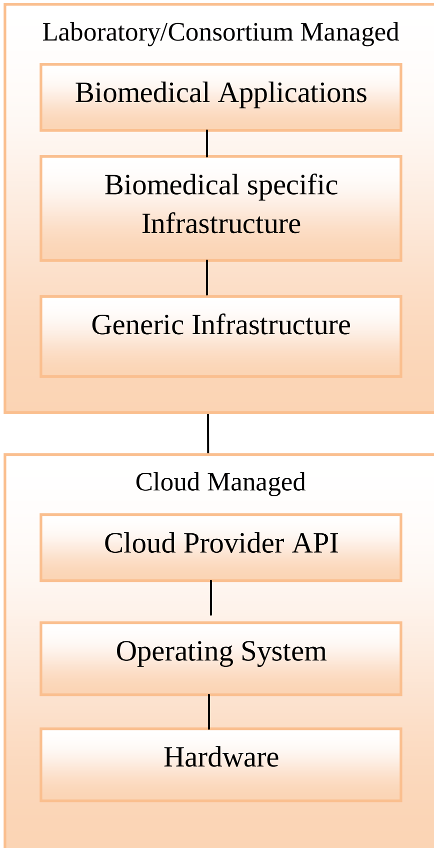
Figure 2. A generic Computing Infrastructure Employed at Local Laboratories, Managed by the Laboratory Itself or A Consortium for Data Sharing (Rosenthal et al., 2010)



2.2. Bio Medical Cloud

We argue that an interconnected network of data centre scale facilities (loosely speaking 'clouds') with the appropriate security architecture and a rich set of secure inter cloud services is the proper foundation for the biomedical-infomics synthesis. Call this the Biomedical Cloud. It is an example of a community cloud . It could be filled with all publicly available data relevant to biology, medicine and health care. Like the data in commercial search engines, such a repository would be accessible to individuals via personal devices, with the compute intensive operations being performed in data centers and associated high-performance computing facilities. Moreover, secure private clouds and clinical research data warehouses located at medical centres and hospitals containing EMRs, and other data with protected health information (PHI) information could be enriched with data from the community Biomedical Cloud. Figure 3 (Rosenthal et al., 2010) illustrates graphically the layers that cloud offerings often allow to be offloaded.

Figure 3. Clouds Can Offload the Responsibility of the Bottom two Layers of A Basic Computing Infrastructure (Rosenthal et al., 2010)



3. SERVICE-ORIENTED MULTI-AGENT CLOUD COMPUTING ARCHITECTURE

This section firstly introduces SOA and Multi-agent technology; secondly, cloud service Qos model; finally, a Service-Oriented QOS-Assured and Multi-Agent cloud computing architecture is designed to support QOS-assured cloud service provision and request.

3.1. SOA and Multi-Agent Technology

There are advantages for service management and architect-driven concept in the SOA. Currently, cloud computing technology has hardly any service management and architect-driven concept. So, the idea of service management and architect driven can be applied to cloud computing. By this, cloud computing can be seen an extension which SOA provides resources to "cloud", such as, IaaS, PaaS, SaaS, and its key is to determine which cloud services, information and processes on the cloud is the best candidate, and which cloud services should be abstracted in the existing or emerging SOA. Software agent is a software entity which runs continuous and independent in a given environment, usually combined other agents with solving problem . Multi-Agent system has been increasingly attracted to researchers in various fields, particularly in the network environment, agent can be used to complete complex task by communicating with many resources and task publishers. Cloud computing refers to both the applications delivered as services over internet and hardware and systems software in the datacenters, and it provides a variety of resources, such as network, storage, computing resources to users adopted by IaaS, PaaS, SaaS and other forms of service. These resources are vast, heterogeneous, distributed; it is very important how to provide them to users with high-quality, validity. Described by the above, agent can be used to complete complex task by communicating with many resources and task publishers. So, it can be used in service-oriented cloud computing architecture to support QOS-Assured cloud service provision and request.

3.2. Cloud Service Qos Model

Taking into account strong background resource process and service provision capabilities, this paper considers all related QOS attributes of cloud service consumer and cloud service providers. As far as cloud service providers, cloud service Qos provided by the physical device and virtual resources layer mainly focus on data center's performance, reliability, stability; cloud service Qos provided by Iaas likely emphasize on response time, resource utilization, and prices, and so on. As far as cloud service consumers, they are very important, such as, response time, price, availability, reliability, reputation, and they can also be provided by the service provider.

3.3. Service-Oriented QOS-Assured and Multi-Agent Cloud Computing Architect

Figure 4 shows a Service-Oriented QOS-Assured and Multi-Agent cloud computing architecture which includes physical device and virtual resource layer, cloud service provision layer, cloud service management and Multi-Agent layer, to support QOS assured cloud service provision and request.

1. **Physical Device and Virtual Resource Layer**

Physical resources is all kinds of physical equipment which support upper services of cloud computing, such as a large number of servers in data center, network equipment, storage equipment and so on. Cloud computing is a shared-resource computing method by the form of virtualization. Here, physical resources can be converted into various resources, such as computing resources, storage resources, network resources by virtualization technology, then they can be connected together to form a flexible, unified resources pool in order to dynamically allocated to different applications and service requirement, thereby improve resources utilization rate.

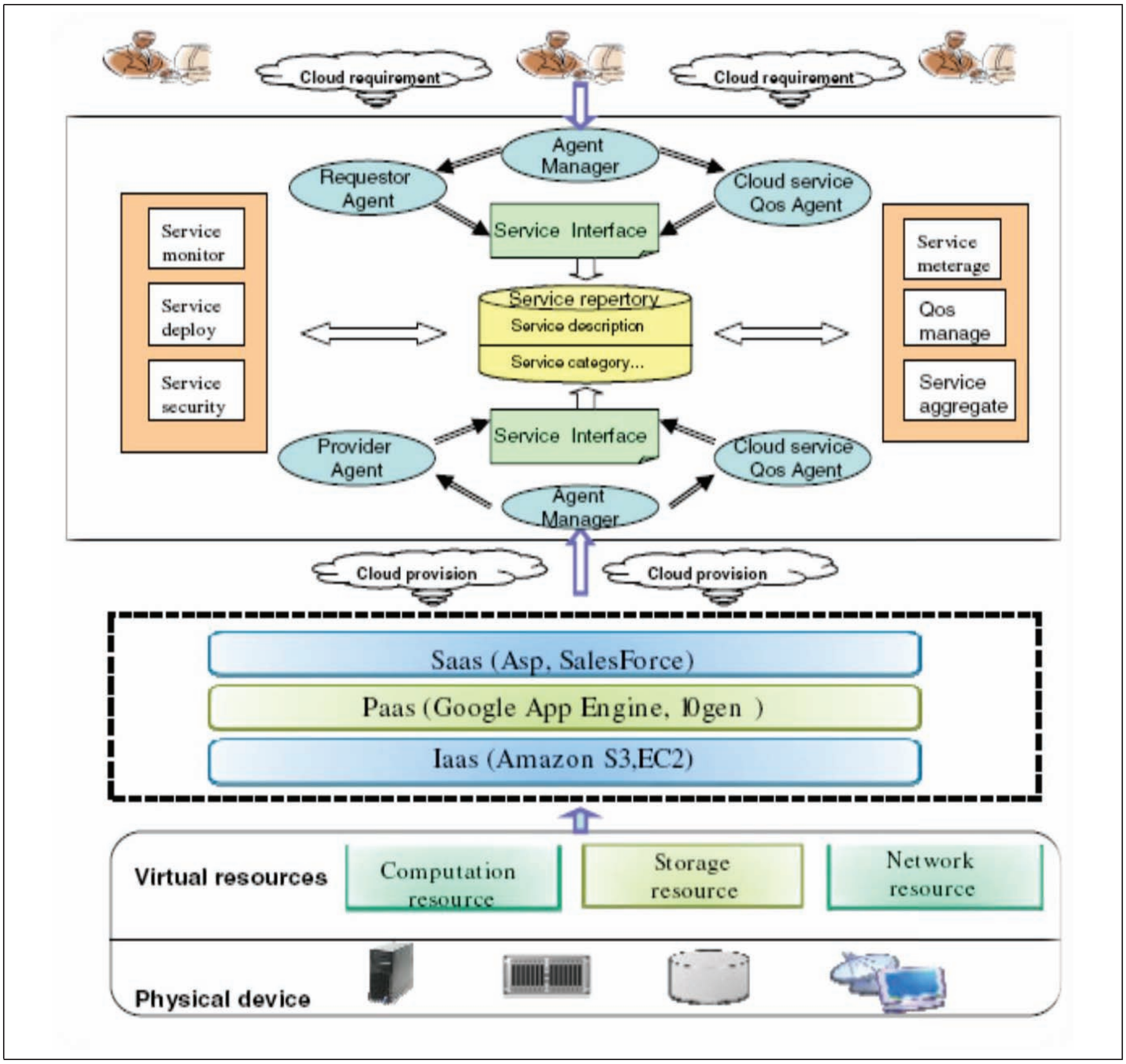
2. **Cloud Service Provision Layer**

Cloud service provision layer can provide some forms of services by functions composition provided by physical device and virtual resource layer. The forms of service that cloud computing provides today may be broken down into managed services, SaaS, Web services, utility computing, and PaaS. Figure 4 shows a concentrated services view of cloud computing, including Iaas, Paas, and Saas, which provide IT service capabilities to users.

3. **Cloud Service Manager and Multi-Agent Layer**

Cloud service manager and multi-agent layer mostly manages a variety of services provided by cloud service provision layer and finds QOS-assured cloud service in service repertory according to user's cloud service requirement. As shown in Figure 4, cloud services management which includes service repertory, service interface, service aggregate, service monitor, service deploy, service meter age, service security, QOS manage. Among them, service repertory similar to UDDI in the SOA, which includes service description, service category, and so on. Service description represents service functional and non-functional information, such as service names, response time, and so on; service category represents service type provided by cloud service provision layer, such as IaaS, Saas, Paas; service interface represents access interface according to services types, for example, Remote Desktop for IaaS, API for PaaS, web services for SaaS; service aggregate represents that new services can be created based on existing services; service monitor represents monitor and alarm according to health status of the services and automatically correct abnormity state of services; service deploy represents automatically deploy and configure specific services

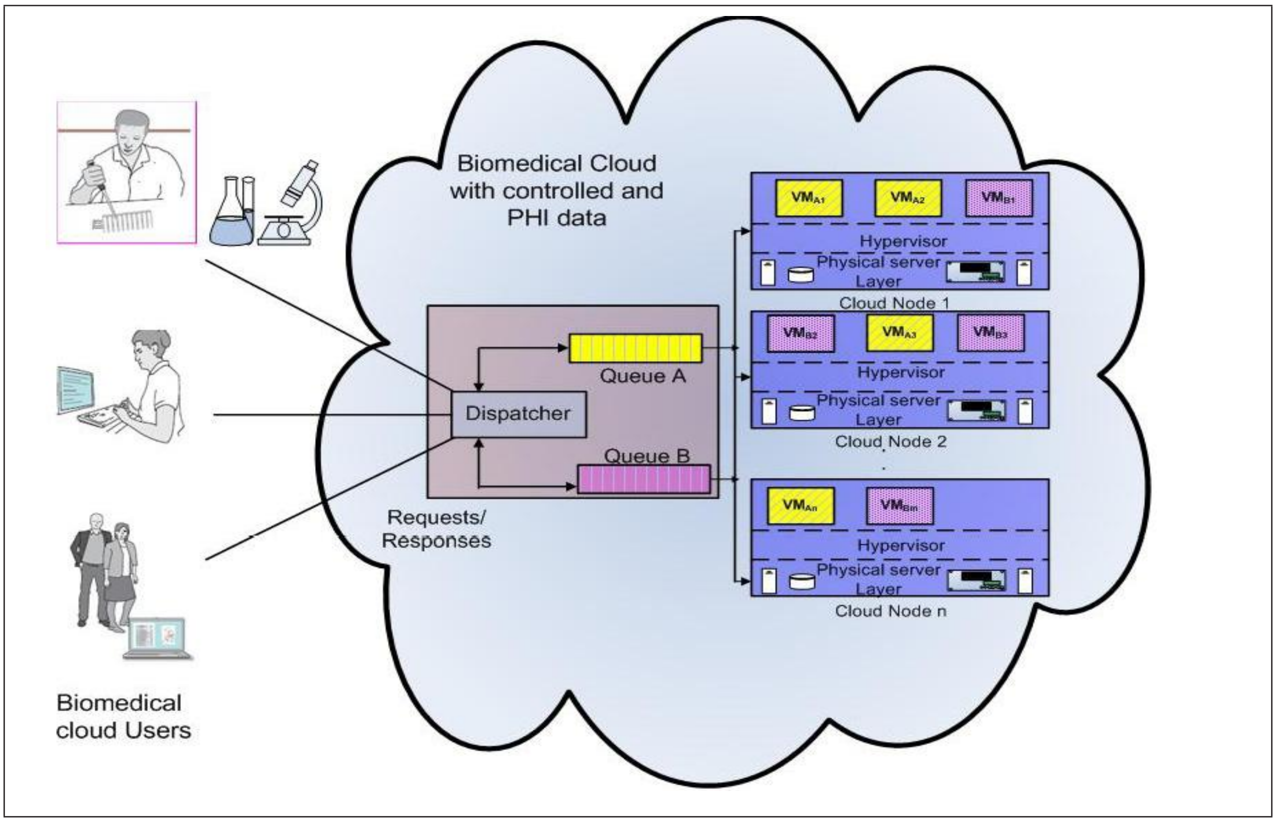
Figure 4. Service-Oriented and Multi-Agent Cloud Computing Architecture (Cao et al, 2009)



examples according to users requirements; service meter age represents cloud services, similar to water, electricity and gas, which are available and pay on-demand by the user; service security represents provide authorization control, trust management, auditing, consistency check for cloud services; QOS manage represents that manage cloud service Qos model which select, calculate and dimensionless process Qos attributes and described in section 3.2, at the same time, sustain the extension of QOS attributes, that is can add or remove QOS attributes according to specific situation, to support QOS-assured cloud service acquired at any time, used on-demand, pay-per-use and extended indefinitely, and return the best expected cloud service to user. Cloud multi-agent management which includes cloud service requestor agent, cloud service QOS agent, cloud service provider agent and agent manager, and it is mainly support QOS-assured cloud service provision and request.

Cloud services requester is no longer direct visit cloud service but commit to requestor agent, who mainly collects feedback information of request and submits cloud service request based on QOS. Similarly, Cloud services provider is no longer direct publish services but commit to provider agent, who mainly collects cloud service use information and publishes cloud service. Cloud service QOS agent

Figure 5. Queue Model of Biomedical Applications on Cloud



primarily submits cloud services QOS information. Agent manager primarily manages various managers, such as new, recovery operation. Thus, the process of cloud service provision can be described: First of all, Cloud service provision layer can provide various cloud service to agent manager and then establish provider agent and cloud service QOS agent. Secondly, service function information, such as service description, service category, which can be standardized by service interface, will be submitted to service repertory by provider agent. At the same time, service QOS information, such as, response time, cost, which can be standardized by service interface, will be submitted to service repertory by cloud service QOS agent. The process of cloud service request is the same to the process of cloud service provision.

We consider a finite buffer queueing system with queue dependent multi-heterogeneous VMs server which is shown in Figure 5.

4. NUMERICAL ILLUSTRATION

This section illustrates the numerical tractability of the optimal threshold policy provided. A computational program is developed by using MATLAB. For validity of analytical results, we compute numerical results for the following models.

The heterogeneous VMs turn on one by one with the arrival of each customer. That is, N_i=N_i+2. We set $\mu_i = 1 + 0.2(i-1)$.

Figure 6. Impact of L on λ for Various VMs

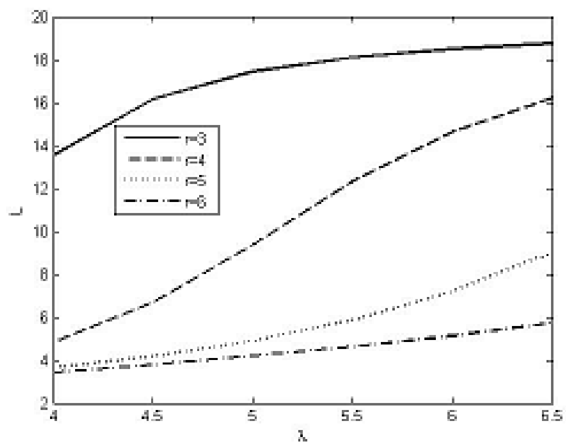
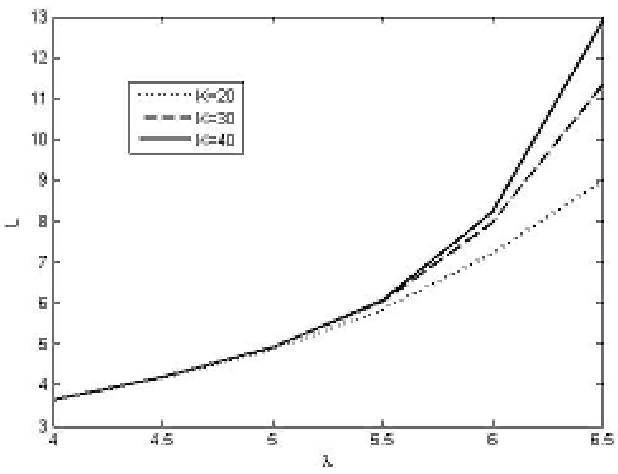


Figure 7. Impact of L on λ for Different Buffer Size



Figures 6 and 7 depict the average number of customers (L) in the system versus arrival rate λ by varying the number of servers and by varying the buffer size, respectively. It is seen that the average number of customers (L) in the system increases with the arrival rate λ .

5. CONCLUSION

We introduced cloud architectures for biomedical informatics who may wish to build applications using a cloud, and for investigators who want to share data with collaborators. Multi-Agent data Intensive architecture facilitates the development of dynamic and intelligent multi-agent systems. Its model is based on a Cloud Computing approach where functionalities are implemented using web Services. We employed the finite buffer multiserver system with queue dependent heterogeneous servers, the number of servers changes depending on the waiting customers. The service load in cloud computing is dynamically scaled up and down depending upon end users service requests. It will be useful in the services performance prediction of cloud computing.

REFERENCES

1. Bojanova, I. & Samba, A. (2011). *Analysis of cloud computing delivery architecture models*. In Proceedings of International Conference on Advanced Information Networking and Applications (pp. 445-458)
2. Buyya, R., Yeo, C. S. & Venugopal, S. (2008). *Market Oriented cloud computing: Vision, hype and reality for delivering IT services as computing utilities*. In Proceedings of the 10th IEEE International Conference on the High Performance Computing and Communications (pp. 5-13).
3. Cao, B. Q., Li, B. & Xia, Q. M. (2009). A service-oriented QoS-assured and multi-agent cloud computing architecture. *Cloud Computing* (pp. 644-649). Berlin Heidelberg: Springer.
4. Chaudhry, M. L. & Templeton, J. G. C. (1983). *A First Course in Bulk Queues*. New York: John Wiley & Sons.
5. Chung, J. M. (2000). *Analysis of MPLS Traffic Engineering*. In Proceedings of 43rd IEEE Midwest Symposium on Circuits and Systems (pp. 550-553).
6. Foster, I. & Kesselman, C. (1999). *The Grid: Blue Print for a New Computing Infrastructure*. San Francisco: Morgen Kaufmann.
7. Foster, I., Fidler, M., Roy, A., Sander, V. & Winkler, L. (2004). End to end quality of service for high end applications. *Computer Communications*, 27(12), 1375-1388.
8. Iosup, A., Ostermann, S., Yigitbasi, M. N., Prodan, R., Fahringer, T. & Epema, D. H. J. (2011). *Performance Analysis of Cloud Computing Services for Many-Tasks Scientific Computing*. IEEE Transactions on Parallel and Distributed Systems, 22(6), 931-945.
9. Medhi, J. (2003). *Stochastic Models in Queueing Theory* (2nd ed.) Academic Press Inc.
10. Rimal, B. P. & Eunmi, C. L. (2009). *A Taxonomy and survey of cloud computing systems*. In Proceedings of the Fifth International Joint Conference on INC, IMS and IDC (pp. 47-51).
11. Rittinghouse, J. W. & Ransome, J. F. (2010). C*loud Computing, Implementation, Management and Security*. CRC Press.
12. Rosenthal, A., Mork, P., Li, M. H., Stanford, J., Koester, D. & Reynolds, P. (2010). Cloud computing: A new business paradigm for biomedical information sharing. *Journal of Biomedical Informatics*, 43(2), 342-353.
13. Vouk, M. (2008). Cloud Computing - Issues, Research and Implementations. *Journal of Computing and Information Technology*, 16(4), 235-246.
14. Wang, L., Laszewski, G. Von, Younge, A., He, A., Kunze, M., Tao, J. & Fu, C. (2010). Cloud computing a perspective study. *New Generation Computing*, 28(2), 137-146.

15. Xiong, K. & Perros, H. (2009). *Service performance and analysis in cloud computing*. In Proceedings of IEEE World Conference on Services (pp. 693-700).

16. Yang, Y., Zhou, Y., Liang, L. & Dan, H. (2010). *A service oriented Broker for Bulk Data Transfer in Cloud Computing*. In Proceedings of Ninth International Conference on Grid and Cloud Computing (pp. 264-269).