Evaluation by Simulation of the Diffusion Methods in the Cloud: Based Network Architecture for Digital Open Universities

Boukar Abatchia Nicolas, Mahamadou Issoufou Tiado, Nassirou Adamou Hassane and Ibrahim Ganaou Noura

Department of Mathematics and Computer Science, Research Team on Network and Tele-communication, University of Abdou Moumouni, BP 10662 Niamey, Niger

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Abstract: The interconnection between the Internet and the telecommunication networks brings to the advent of the new generation of digital open universities (DOUNG). That recent model was improved through many additional works including the extension of its architecture from the Local Area Network (LAN) to the Internet and to the GSM (Global System for Mobile communications) environment. This hybrid architecture leads to several connections with the goal to achieve a good level of Quality of Service (QoS). One solution belongs to the using of clouds with the issue of choosing a diffusion method adapted to this new context. In this paper, a comparative study of flow distribution methods is conduct through dissemination issue and simulations. We extend that work with the cloud contribution assessment including scales evaluation. All results for vertical and horizontal scaling and for the unicast and multicast methods are produced and discussed.

1 INTRODUCTION

The DOUNG architecture (Tiado and all, 2013) is based on the Internet and the GSM from the wired and wireless LAN. The service extension to the GSM leads to several architectural solutions. Authors of document (Tawayé and all, 2021) suggest implementing an integrated server model (ISM) by hosting mirror server at the GSM side with crossing the Internet network. The idea here is to use clouds in the global architecture to achieve a good level of QoS. To evaluate the gains of this new model, it becomes important to consider the method of flow dissemination and the clouds distribution. The contribution assessment is conduct through the criteria of the global resources consumption in the data center and at the run time. The goal is to evaluate the system load for QoS performance, and the processing time with the resource scaling which indicates the optimization of their consumption

2 THE INTEGRATED SERVER MODEL

The ISM describes the DOUNG architecture with a mirror server hosted by the GSM Service Provider (GSP) in addition to other services chain. Learners with cellular devices can access this server locally, which in turn maintains a sufficiently fluid connection with that of the backbone to make operational the synchronous course monitoring mode. The problem of crossing the Internet network is resolved through models for ensuring a minimum quality of service using VPN (Virtual Private Network) (Zhengchun and Tongcheng, 2021), (Mohd F. and all, 2021), (Yunxiao S., and all, 2021), or MPLS (Multi-Protocol Label Switching) (Faycal B. and Najib K., 2019), (Anju B. and V.P.Singh, 2016) or with IntServ (Integrated Services) and DiffServ (Differentiated Services) (Abdullah Y. and Tolga G., 2014). The figure 1 below summarizes the architecture of this extended model.

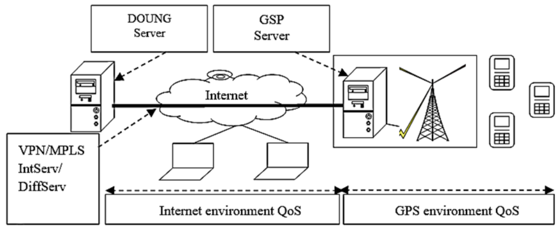

Figure 1: DOUNG architecture extension with ad hoc network.

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3 NEW ARCHITECTURE WITH INCLUSION OF CLOUDS

Clouds are integrated in the initial model of the DOUNG to overcome the problems of nodes lacking in terms of storage and processing capacity such as cellular devices. In further work, the suggestion of the ATRS (Advanced Text Reading System) is intended to strengthen this contribution (Tiado and all, 2015). In document (Tiado and all, 2021), the solution of the blackboard image transmission with the voice of the teacher directed the additional works towards the transcription of the voice for its conversion into text format to facilitate its transport through the Internet network. At the entrance of the GSM network, this text stream is reconverted into audio by the ATRS. The using of the cloud helps to offload the GSP mirror server and to specialize it in the repatriation of data streams from the DOUNG server. In this section, we extend the clouds exploitation with two complementary levels in addition to the GSM internal cloud. A first extension consists of using a private cloud in the backbone of the DOUNG and a second extension allows to use a public cloud to facilitate access to learners via the Internet network. The expected gain is to obtain better QoS both with the course warehouse storage and with the use of cloud resources (CPU – Central Process Unit, RAM – Random Access Memory, etc.) during live sessions of classes.

3.1 The Improved Model

The figure 2 shows the LAN (Local Area Network) and the WLAN (Wireless LAN) standing as the backbone of the DOUNG with the interconnection of the GSP mirror server. The last two environments host private clouds. The need of QoS in the link between the backbone and the public cloud, same as the link toward the GSP, find solution within the three methods including VPN, MPLS or IntServ and DiffServ. The GSP network is part of the WAN (Wide AN) with the possible inclusion of WiMAX technology and other technologies depending on the networks evolution.

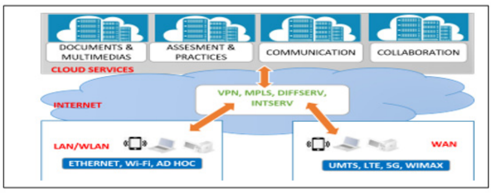


Figure 2: Model of the general architecture of the DOUNG network

3.2 Clouds Distribution

The use of clouds by the DOUNG can be realized through three architectures: the Internet public cloud, the DOUNG backbone private cloud and the GSP private cloud.

Local Private Cloud Integration

In this model, all services are hosted in a private cloud deployed in the DOUNG main site. The cloud is however accessible from the Internet. Lessons are produced and delivered directly to learners from this cloud.

Public Cloud Integration

In this complementary model, all DOUNG services are hosted in a public cloud. Lessons are produced by the DOUNG and conveyed in this environment. The learners most advantaged by this architecture access lessons from the cloud.

Integration of the Private Cloud in the GSM Environment

The previously model is extended with the addition of a private cloud within GSM networks. This cloud hosts temporary storage services and is used for traffic filtering as well as all DOUNG services to facilitate their access by mobile devices.

Final Hybrid Architecture

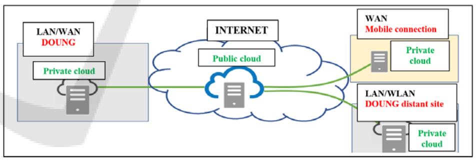


Figure 3: Architecture pattern with hybrid clouds.

4 COMPARATIVE STUDY OF FLOW DISTRIBUTION METHODS

Several metrics can be used to measure the performance of our architecture according to the cloud QoS metrics. These include performance, safety (reliability), and configuration. For performance metrics, the available settings are response time, processing time, service throughput, data transfer rate, and latency. Dependability parameters relate to availability, elasticity, reliability, time independence, resilience, and scalability. Finally, configuration metrics have parameters including virtual systems and location.

For the performance gains evaluation of our architecture, in the first place, we are particularly interested by the bandwidth and the rate of losses. The first parameter is assimilated to the throughput of the service included in the performance metrics. The second parameter assimilated to the reliability of the service belongs to the dependability metrics. These parameters will help to determine the distribution method best suited to our context among the three that can be used.

4.1 Dissemination Issue

The new DOUNG network architecture allows a learner to follow a course synchronously by consuming a cloud service locally, via the Internet or in the GSM. To study and evaluate the QoS gains of this technology, we first carry out a comparative study of multimedia stream broadcasting techniques to determine the best suited to real-time course monitoring. For this, we use the NS2 and CloudSim simulators to test our scenarios presented in the table 1. In a general way and in a computer network, there are three modes or methods of diffusion usable for the routing of data flow:

Broadcast: the source server stream is intended for all connected clients. This type of broadcast is used for applications such as IPTV (Internet Protocol Television).

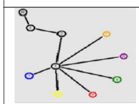
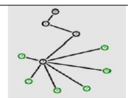
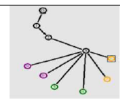
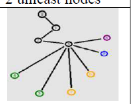
Multicast: the source server stream is intended for a specific group of clients.

Unicast: the client connected to the server receives its own stream.

4.2 Description of Scenarios

It is possible to classify learners into three categories. The first category concerns learners directly connected to local domains (LAN, WLAN and ad hoc). The second category concerns GSM learners and the third is that of learners connected from an Internet access provider. According to the objectives set by the DOUNG, these learners benefit from flexible access to the synchronous service of the course. How-ever, a first level of analysis allows to consider that the broadcast mode does not comply with these objectives. Indeed, it does not offer flexibility to learners for having control over the synchronous flow of multimedia data. Therefore, we proceed to an evaluation of the two multicast and unicast methods through four scenarios. We calculate for each case the bandwidth consumed and the loss rate. We use VBR (Variable Bit Rate) traffic for this in the range of [448 to 648] Kbps. The following table presents the topologies used for the simulations by varying the nature of the topology and the diffusion methods. Likewise, this table specifies the direction of the traffic as well as the available bandwidth and the transmission delay of each network link.

Table 1: Topologies used for simulations of diffusion methods.

Scenario 1 (Unicast)	Scenario 2 (Multicast)	Scenario 3 (Multicast)	Scenario 4 Hybrid
1 server 3 routers 6 clients	1 server 3 routers 1 group of 6 mul-ticast client	1 server 3 routers 3 groups of 2 multicast clients	1 server 3 routers 2 groups of 2 multicast nodes 2 unicast nodes
			
Description of traffic direction, bandwidth and delay for each model Legend: (x) → (y) z Mb, t ms Traffic direction from node x to node y with z Mb bandwidth and t ms delay (0) → (1) : 10 Mb, 10 ms (1) → (2) : 10 Mb, 10 ms (2) → (3) : 10 Mb, 20 ms (3) → (4) : 2 Mb, 20 ms (3) → (5) : 2 Mb, 20 ms (3) → (6) : 1 Mb , 20 ms (3) → (7) : 1 Mb , 20 ms (3) → (8): 0.5 Mb , 20 ms (3) → (9) : 0.5 Mb, 20 ms			

4.3 Simulation Results

The following table gives the results obtained for the four scenarios. It is followed by the corresponding graph.

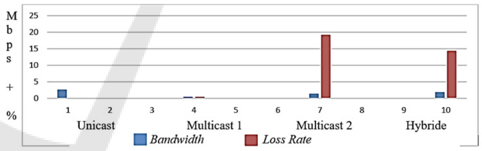


Figure 4: Bandwidth and loss rate of diffusion methods.

The previous results produced under NS2 demonstrate that the single-group multicast mode despite its performance proves to be inefficient for its non-conformity to reality and its lack of flexibility. The second multi-group multicast mode is closer to the reality of DOUNG with learners scattered around the world, but it is handicapped by a high error rate. Unicast mode produces less loss rate but generates high band-width consumption and cannot be implemented exclusively at the risk of overloading the DOUNG server and causing an explosion in bandwidth consumption. There-fore, after the synthesis of these results, we adopted the hybrid broadcast model for its flexibility (unicast and multicast) allowing some learners in the DOUNG domain to join multicast groups while a second category is connected in unicast depending on the load supported by the server. This model allows to reduce the network load and consequently improves the QoS of the synchronous mode of course monitoring.

5 COMPARATIVE STUDY OF FLOW DISTRIBUTION METHODS

We are interested here by the global resources consumption (GRC) (CPU, RAM, Number of VMs: virtual machines) in the data center and at the Run Time of the Tasks (RTTk) defined for each scenario. The first parameter is used as an indicator of the system load in the cloud while the second is integrated into performance related QoS metrics, including processing time. This second group of parameters is evaluated with the resource scaling (increase) which indicates the optimization of their consumption during the execution of each scenario. The simulation is related to every cloud of the three architectures presented above (LAN, Internet, GSM).

5.1 Evaluation of Scales

The main characteristics of a good QoS in a cloud are scalability and elasticity. In this part, we study the scaling and load-balancing models allowing horizontal autoscaling (creation of new VMs) and vertical (increase CPU, RAM, Bandwidth) while managing the allocation of learners to the appropriate servers. A readjustment function for this affection is provided to optimize the use of resources and guarantee the performance and reliability of the services. These models are evaluated by simulation with CloudSim which is a tool (Java Library) for simulating cloud computing scenarios. It provides classes allowing to describe for a cloud, the data centres (Datacentre), the virtual machines (Vm), the applications (Cloudlet or Tasks), the users, the computational resources, the strategies for managing these resources and the load distribution strategies. This set allows to evaluate the performance of clouds with new models within calculation and scheduling algorithms

5.2 Simulation Scenarios and Parameters

The objective of this simulation is to evaluate the computing resources consumption (CPU, RAM, Storage) and performance (execution time, response time) for a better QoS of monitoring the DOUNG course in synchronous mode. We propose different scenarios highlighting vertical and horizontal scaling strategies to deter-mine resource utilization and task execution time through the following combinations:

Scenario 1: does not apply scaling;
Scenario 2: vertical scaling of the CPU;
Scenario 3: RAM vertical scaling;
Scenario 4: horizontal scaling of VM;
Scenario 5; CPU and RAM vertical scaling;
Scenario 6: VMs horizontal scaling and the CPU vertical scaling;
Scenario 7: horizontal scaling of VMs and vertical scaling of RAM;
Scenario 8: the VMs horizontal scaling with the CPU+RAM vertical scaling;

The global parameters of the simulation are the following:
15 physical machines of 2 GB of RAM, 100 GB of hard disk, 4 CPUs and 10 GB of bandwidth with a processor of 1000 MIPS (Millions of Instructions Per Second);
At start-up, 4 virtual machines are created of 1 GB of RAM, 10 GB of hard disk, 2 CPU and 10 GB of bandwidth with a processor of 1000 MIPS each. They are allocated to 100 tasks of size 2000 MI (Million Instructions) each.
The scenario evolves with the addition of 20 tasks of size 2000 MI each in the interval [0, 50] seconds during the simulation.
The time-sharing strategy is used for VMs and tasks.
Horizontal scaling creates 12 new virtual machines.
The results illustrated in the figure 4 indicate the overall use of resources (CPU, RAM, Number of VMs) in the data center and the task execution time.

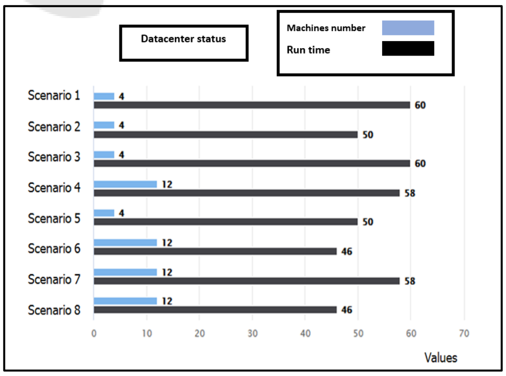


Figure 5: Summary of scaling results.

The previous figure allows to assess the performance gains in the eight (8) scenarios. With the increase in the system load previously described, the simulation results show that CPU vertical scaling is very efficient for good performance and good QoS in the cloud with run time equal to 50 seconds. This is complemented by horizontal scaling in the VM-CPU and VM-CPU-RAM scenarios in which the execution time increases to 46 seconds. However, it also requires the availability of a minimum of resources for its operation. It should also be noted that the vertical scaling of the RAM does not act enough on the execution time which, as we can notice, re-mains intact in the scenarios which involve it as in the same scenario where it is not used (example result without scaling = result with RAM scaling = 60 seconds).

6 CONCLUSION

The evolution of the DOUNG model leads to consider the constraints of facilitating access and ensuring an appreciable level of QoS. To solve the QoS problem of crossing the Internet for the link between the LAN and the GSM, the ISM model has been proposed using VPN, MPLS or the association of the IntServ and DiffServ protocols. One of the contributions developed in this paper relates to the inclusion of cloud technology. Thus, to evaluate the performance gains in QoS that can be achieved, we have carried out a comparative study of the methods of streaming flows and defined simulation scenarios. It appears from this study that the hybrid broadcasting method (unicast and multicast) offers flexibility of choice to learners, reduces the network load, and consequently improves the QoS of the synchronous mode of course monitoring. As a prelude to the prospect of evaluating by simulation the contribution of the clouds, an evaluation of the scaling was carried out with new scenarios and simulation parameters. A next step will consist in comparing the performance gains obtained between the architectures including and excluding the use of clouds.

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