

24-Jul-2015

Dear Prof. Prendinger:

Manuscript ID TOMACS-2015-0009 entitled "DiVE: a Scalable Networking Framework for Distributed Virtual Environments" which you submitted to the Transactions on Modeling and Computer Simulation, has been reviewed. The comments of the reviewer(s) are included at the bottom of this letter.

The associate editor and reviewers have recommended a major revision before a final decision can be made on the publishability of this paper in TOMACS. Therefore, I invite you to respond to the enclosed comments and revise your manuscript.

To submit your revised manuscript, log into <https://mc.manuscriptcentral.com/tomacs> and enter your Author Center, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision.

You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript using a word processing program and save it on your computer. Please also highlight the changes to your manuscript within the document by using the track changes mode in MS Word or by using bold or colored text.

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When submitting your revised manuscript, you will be able to respond to the comments made by the reviewer(s) in the space provided. You can use this space to document any changes you make to the original manuscript. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response to the reviewer(s).

IMPORTANT: Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

Because we are trying to facilitate timely publication of manuscripts submitted to the Transactions on Modeling and Computer Simulation, your revised manuscript should be uploaded as soon as possible, but no later than 21-Nov-2015. If it is not possible for you to submit your revision by this due date, we may have to consider your paper as a new submission.

Once again, thank you for submitting your manuscript to the Transactions on Modeling and Computer Simulation and I look forward to receiving your revision.

Best Regards,

Adeline Uhrmacher

Editor in Chief, Transactions on Modeling and Computer Simulation lin@informatik.uni-rostock.de

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Editor(s)' Comments to Author
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Associate Editor

Comments to the Author:

The paper has two main components: 1) presentation of the architecture of DiVE and 2) investigation of optimal area-of-interest-to-zone-size ratio. These topics are suitably interesting to the TOMACS community.

However, I agree with the two reviewers that the paper is not at present acceptable for publication. My two primary concerns are related to but slightly different than those presented by the reviewers.

1) Organization and writing. The first half of the abstract focuses on the overall DiVE system. The second half emphasizes the interest management component of DiVE. Though perhaps a bit picky, I'm left wondering what the authors consider the primary contribution.

If it is the overall DiVE system, then the paper should be significantly reorganized to present DiVE architecture details earlier on instead of waiting until half way through the paper (Section 4).

If instead the main result is the investigation and analysis of AOI/zone issues, then the abstract should be reorganized and some of the DiVE architecture information in Section 4 made more succinct.

I understand that the answer could be something like "it's a combination of the two ..." Even so, I think the paper's organization should be improved. The first half of the paper concentrate on AOI/interest management while the first part of the abstract focuses on general DiVE ...

2) At least as importantly, my feeling is that the investigation, analysis, and results of the AOI-to-zone-size issues is not strong enough for journal publication. Other papers (some but not all cited by the authors) have investigated AOI/zone issues in some detail. The kind of analysis discussed in 3.4, "Setting an Optimal Size for AOI", is potentially very interesting. Done thoroughly, on a large carefully chosen set of situations, results could make a strong contribution. (An example paper discussing the issue in more detail than this one is: Gary Tan, Rassul Ayani, YuSong Zhang, and Farshad Moradi. 2000c. Grid-based data management in distributed simulation. In Proceedings of the 33rd Annual Simulation Symposium (SS'00). IEEE Computer Society, Washington, DC.). But the given analysis seems simplistic and the conclusion that 2 is a good ratio does not seem very well supported at all. (I also found it odd that the charts and the discussion pretty much ignores ratios less than 1. There is data in the charts for ratios < 1, but it's hard to see and not discussed. Certainly in some applications ratios less than 1 are quite good!)

Summary recommendation: I believe that the DiVE framework is somewhat interesting and potentially warrants publication in TOMACS. If DiVE is to be the primary focus, however, I think better, more careful comparison with other frameworks should be done. I understand the comparisons with Second Life and OpenSimulator. However, I would also like to see a bit more careful discussion of relationship to other frameworks used in, e.g., MMOGs. Without this the impact/interested audience is pretty small. If the primary focus of the paper is interest management, then the abstract should be reorganized, some of the DiVE system info in 4 shortened, and, most importantly, additional work on optimality analysis should be done and carefully presented. Taking a "half interest management / half DiVE architecture approach" seems a bit hard to sell but could be done. E.g., by starting with DiVE architecture and then, in second half not first, presenting key feature of interest management. Thus, I recommend major revision before considering acceptance.

Some additional points:

I agree with one of the reviewers that DiVE is an unfortunate name and think it would be best to change it. For better or worse, the Swedish VE system DIVE from the 1990s is commonly referenced in the VE community and will yield unnecessary confusion.

Sec. 3.2's demonstration of quadratic vs. linear behavior of basic techniques is unnecessary and somewhat of a "straw man." Indeed, the focus on n^2 as the alternative is a bit too simple. E.g., techniques using sweep-and-prune algorithms, commonly used for intersection/collisions detection of axis-aligned-bounding-boxes, yield significant practical improvements over naive n^2 methods. Hybrids that combine sweep-and-prune with zone/grid methods can be very practical and efficient.

In Section 3.4 the focus on "number of messages" and "number of 'entering/leaving zone' events" is a bit mysterious to me. How do those numbers relate to overall run time?

Also, Figure 7 should be split into two rather than have two pretty different sets of data overlaid on the same chart - I see no insight added (and only potential confusion) by having them in the same place - the numbers are not directly comparable, e.g.

In 5.3, Results of Systematic Testing, there is not much said about the Local vs Optimized zones. From a quick look at the charts, I think many would say the Optimized results are not obviously better, certainly not enough so to be sure in a variety of situations beyond the simple few tested.

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Reviewer(s)' Comments to Author

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Referee: 1

Comments to the Author

This paper addresses the scalability challenge in disseminating updates in multi-user virtual environments (VEs) and proposes a region-based area of interest (AOI) technique to control the number of updates transmitted over the network. Although the idea of region-based AOI is not new, this paper evaluates costs and benefits of different region sizes and proposes heuristics on choosing an appropriate region size given the AOI size and some movement patterns of users in the VEs. It also presents the DiVE communication architecture based on the proposed region-based AOI technique.

The paper is well written and well organized. The strength of the paper is the zone-based AOI algorithm, where it applies the idea of a buffered area around each entity's AOI to avoid frequent zone subscription/unsubscription, and proposes an optimal size of AOI is set by applying a set of different entity movement patterns. In addition, DiVE has been applied in several virtual world applications and validated its effectiveness in supporting those applications.

The concerns that the reviewer has are as follows:

The Distributed Virtual Environment usages it supports is limited. Due to the design and the validate method (validated in LAN setup only), it's not convincing that it can become a networking framework in general to support massively multi-user virtual worlds and scales to the level as claimed in the paper.

DiVE seems to support a certain types of VE applications: multi-user 3D games, in which users mainly control an entity (avatar or vehicle), and the content of the VE can be preloaded at each client machine and do not change during the game plays. The major updates in these games are position updates of the entities, and in general no concurrent controls of the same entity (hence avoiding consistency challenges) would happen. In addition, all the experiments for DiVE evaluation were done within a LAN networking setup, where networking delay was not a big issue. Such games and network setup make it possible that simulations happen on the client machines, and servers only collect and disseminate position updates in time to keep states in client machines consistent. However, there are many types of distributed VEs than the type discussed above. For instance, there are VEs in which the simulation is not only the movements of avatars or vehicles, but also complex simulations of object behaviors. There are also VEs that client machines are not trusted for running simulations or not powerful enough to run the simulations, VEs that need to support clients globally, and VEs with user-created content that is hard to be pre-loaded into client machines (such as Second Life type of virtual worlds).

There are several limitations of DiVE. First, DiVE handles the simulation scalability problem by running simulation on client machines and letting each client simulate its own entity's movement. This puts strong requirements on hardware configuration and capability of client machines, which limit the types of VE applications that DiVE can support. Second, DiVE does not really address the consistency maintenance of distributed simulations – which would become a significant problem when clients are spread across Internet and experience long network delays. The usages that DiVE supported seemed to run in the same LAN, and hence the network delay was not a big issue. For many distributed VEs, however, client machines at different geo locations would be the norm and network delays need to be addressed. More importantly, it's the inconsistency among the client machines caused by long network delays that need to be addressed. Otherwise, it is not a complete solution.

I'd suggest a major revision, to at least test the system in a WAN setup (e.g. by deploying servers and clients in different sites of public clouds).

Referee: 2

General comments:

This paper is easy to read and clearly presents its experimental evaluations. The most critical issue is, however, the motivation of the research. DVE frameworks and middleware are very common in the literature. The authors should address the existing frameworks and compare them to the proposed DiVE framework. What is missing in the existing frameworks? Why the proposed framework is better than the existing ones? These are the questions the reviewer expects to be answered and thoroughly discussed, with the support of experimental evidence or quantitative analysis.

Moreover, the authors claim that the novelty of this work is to determine the optimal proportion of the size of a zone and the size of the AOI. Although not exactly identical to this problem, the optimal zone size has already been discussed in the literature. The authors may consider to compare the methodologies and results presented in the following four papers.

RAK, S. J. AND VAN HOOK, D. J. 1996. Evaluation of Grid-Based Relevance Filtering for Multicast Group Assignment. In *Proceedings of the 14th DIS Workshop on Standards for the Interoperability of Distributed Simulations*. 739–747.

AYANI, R., MORADI, F., AND TAN, G. 2000. Optimizing cell-size in grid-based DDM. In

Proceedings of the fourteenth workshop on Parallel and Distributed Simulation. PADS'00. IEEE Computer Society, 93–100.

TAN, G., AYANI, R., ZHANG, Y., AND MORADI, F. 2000. Grid-Based Data Management in Distributed Simulation. In Proceedings of the 33rd Annual Simulation Symposium (SS 2000).

DEEN, G., HAMMER, M., BETHENCOURT, J., EIRON, I., THOMAS, J., AND KAUFMAN, J. H. 2006. Running Quake II on a grid. IBM Systems Journal 45, 21–44.

Additional comments:

Page 1, Line 15

The name 'DiVE' is a bit similar to one of the most influential DVE systems--DIVE (Distributed Interactive Virtual Environment)--created by Swedish Institute of Computer Science in the early 1990s. Using another name may help the readers to avoid confusion. The DIVE system can be referred to the following paper: CARLSSON, C. AND HAGSAND, O. 1993. DIVE - A platform for multi-user virtual environments. Computers & Graphics 17, 663–669.

Page 3, Line 23

Is 'OpenSim' an abbreviation of OpenSimulator (Page 1, Line 36)? If so the abbreviation should be defined. Otherwise, a reference of 'OpenSim' should be added.

Page 4, Line 18

The acronym 'AOI' has already been defined (Page 2, Line 34).

Page 7, Section 3.3

The disadvantage of the inner/outer AOI has not been discussed in this section. Assume the inner AOI represents the actual visibility scope of an entity, adding a larger outer AOI may reduce the chance of oscillation, however, the outer AOI would also subscribe to zones that the entity does not see. Consequently, the owner of the entity would have more chance to receive irrelevant data with this approach. For example, in figure 4(b), the 4th case, the entity cannot see the zone but it still receive data from this irrelevant zone.

Experimental evaluation on this disadvantage is also expected.

Page 8, Line 22-23

'With the zone-based approach, the number of AOI checks become independent of the number of entities on the server.'

Section 3.3 describes that two AOIs are associated with each entity. Therefore, the number of AOI checks should definitely be dependent on the number of entities.

Page 8, Line 44

Error sentence: 'So we chose choose 100m² 100.....'

Page 10, Line 28

'Each agent is a thread, each message portal is a thread, and each behavior also requires a thread which increases the execution time significantly.'

The results as they are now presented in Figure 6 cannot explain whether the discrepancy is caused by different movement patterns or different programming models. If the authors want to compare the difference between the three movement patterns, the thread programming model of the agent-based social movement pattern should be replaced by another model that is similar to the other two movement patterns. Alternatively, only the execution time of interest matching

should be measured, not the entire simulation time.

Page 10, Line 45

Is it 'DiVE FRAMEWORK'?

Page 10, Line 50

'Standard Development Kit (SDK)'

Is it Software Development Kit?

Page 16, Line 45

The authors used two paragraphs to describe Lake et al.'s architecture and experimental results. It is unclear how this work is related to the tests described in Section 5.2 and 5.3. A more detailed explanation is expected. Moreover, even if Lake et al.'s work is related to the tests, it would be better to put its detailed description in Section 2, rather than 5.2.

Page 17, Line 5-15

The reviewer fails to see the result described in Line 5-9 indicates the conclusions (1) and (2). A more detailed and comprehensive explanation is expected.

Page 20, Line 5-8

This seems to be an engineering problem. If the connection is overloaded when the number of clients is larger than 120, all of the comparisons (e.g. Fig. 12, bandwidth usage) would become problematic since they failed to reveal the actual difference between the three approaches. Therefore, only the undistorted results should be presented (i.e. when the number of clients is smaller than 120).