International Journal of Computer Networks and Communications Security

VOL. 3, NO. 12, DECEMBER 2015, 432–437
Available online at: www.ijcncs.org
E-ISSN 2308-9830 (Online) / ISSN 2410-0595 (Print)

Challenges for a Global Solution Addressing Quality of Service Problems in P2P IPTV Systems

Ihsan Ullah[1], Waheed Noor[2], M. Javid Iqbal Khan[3], Junaid Baber[4] and Atiq Ahmed[5]

[1, 2, 4, 5] Department of Computer Science & IT, University of Balochistan, Quetta

[3] Directorate of IT, SBK Women's University, Quetta, Balochistan

E-mail: [1]ihsanullah@uob.edu.pk, [2]d.oric@uob.edu.pk, [3]javidkm@yahoo.com, [4]junaidbaber@ieee.org, [5]atiq.ahmed@uob.edu.pk

ABSTRACT

Currently, there are many peer-to-peer (P2P) application layer multicast (ALM) solutions which offer a serious alternative to IP multicast and content delivery networks live video streaming applications. Nonetheless these P2P infrastructures suffer from Quality of Service (QoS) problems due to several causes: dynamics of users' presence, selfish behavior, latency, bandwidth and geographic distance. Several research works address these problems individually, but none of them provides a global solution. In this paper, we show how a solution based on a multi-agent system can solve this problem and the challenges it has to face.

Keywords: *P2P IPTV, Multi-Agent systems, Overlay Networks, Live Video Streaming, Quality of Service.*

1 INTRODUCTION

For the past few years, multimedia content streaming over the Internet has emerged as one of the major applications provided to end users [1]. Several architectures can provide such a service. These include classical client/server (C/S) paradigm, telco-managed Internet Protocol Television (IPTV), Content Delivery Networks (CDN) and P2P networks. Telco-managed IPTV requires IP multicast enabled routers while others do not require any changes at the Internet layer. However, IP multicast could not be deployed at the Internet scale due to several issues [2]: (1) it requires per group states, which is against the stateless nature of protocol IP, (2) it increases complexity, (3) it introduces scaling constraints, and (4) it requires changes at the infrastructural level.

The remaining architectures can be further divided into two groups. The first type does not require any support from end-users' systems while the second type involves end-hosts to store and forward content to other hosts. The former group contains centralized architectures that include client/server and CDN based architectures while the latter one is based on decentralized architecture that consists of P2P networks. C/S and CDN based solutions face scalability issues since during high load they require an increase in servers' capacities and upload bandwidth. This makes these solutions expensive. At the other hand, P2P approach is easy to deploy with low cost and provides better scalability because each user brings resources to the system.

In the P2P research area, a lot of proposals have emerged, using both structured and unstructured topologies. Also, several limits to these approaches have been identified and improvements have been proposed. These mainly concern (1) the need for a geographical optimization of the overlay [3], (2) the consideration of the user behavior in terms of dynamics [4] and (3) the resource share [5]. If these improvements are efficient and worthwhile, the problem which still remains is that including one and ignoring others leads to performance limitations. Incorporating all these measures in one system is complex since optimizing the system for one element may degrade the quality for another element. Therefore, there is a need of an intelligent environment that takes all elements into consideration and chooses the best global option both at the peer level and at the community level. For such a solution we propose to use a multi-agent approach.

The rest of this paper is organized as follows. Section 2 deals with the related work. Section 3 addresses the performance problem in ALM systems. Section 4 presents the agent solution we are currently exploring and the challenges it has to face. Finally, section 5 draws some conclusions and gives directions of future work.

2 RELATED WORK

The research community has shown enormous interest in P2P IPTV systems. Current works address different aspects of these systems. Most of the works focus on overlay design that is resilient against independent arrivals and departures of peers (churn). As a result several types of these systems have been proposed. These systems can be broadly classified in push-based, pull-based and hybrid groups.

Push-based systems [6, 7] form a tree structured overlay in which nodes are arranged in parent/children relationships where a parent peer directly push content to its child peers as it receives it. These systems can efficiently disseminate content but they provide very little resistance against churn. At the other hand, pull-based systems [8, 9] enable peers to form partnerships and pull the content from several peers on explicit requests. These systems provide resilience against churn but lead to larger delays.

Hybrid approach [10-12] attempts to combine the best features of push-based and pull-based approach to provide resilience against churn and timely delivery of content. However, these systems need to intelligently decide which node to use for pushing content and how to keep the overlay stable. Since the stability of the overlay is dependent on the stability of peers that make core of the overlay, and peers are directly dependent upon the user behavior, a plethora of works have been dedicated to user behavior.

A major part of these research activities focus on measurement studies over user behavior [2, 13]. These measurements are based on collecting logs and traces from the deployed systems and analyzing them for different user metrics. Their results provide foundations for modeling user behavior. Based on the insights from measurements, some works propose partial user behavior models that focus on one or a few particular aspects of user behavior [14-17]. Very few works attempt to model user behavior with more metrics at the same time [4, 18, 19] but they do not propose complete system designs for major deployed architectures.

Concerning the resource sharing of peers, in principle, peers in a P2P network must effectively act both as client and server in order to provide a good level of performance. In ALM proposals, due to the protocol itself or selfish behavior, this condition is not always satisfied. Solutions to unfair protocols are addressed by splitting the whole content into chunks and diffusing them on different peers. Thus for a content part, each peer hosting a chunk will act as a root node in the tree [20]. Concerning selfish nodes, incentive approaches are proposed to make them participate actively [21]. The general principle they rely on consists in providing peers with a QoS related to its level of contribution [5].

ALM schemes also face the challenges of delay and packets duplication due to heterogeneous environment and overlay mismatching with the physical network. The proposals that have addressed this problem focus on localization [22] that is construction of an overlay in such a way that the nodes, physically near to each other also remain near in the overlay by looking into the IP addresses [3]. Another criterion to deal with this constraint is to organize nodes in such a structure so that there remains the least delay among the nearest nodes in the overlay [23].

3 PERFORMANCE PROBLEMS IN ALM SYSTEMS

ALM systems are low cost and can be easily deployed. Moreover, they have got potential to scale under heavy load of users but they have got their own issues. We identify two main sources of these problems: (1) the end-user behavior, in terms of dynamics and resource share and (2) network constraints such as bandwidth, latency or geographical distance. We discuss these issues in detail.

3.1 End-User Behavior

In a P2P ALM system, the end-user behavior is a crucial aspect that must be considered since the network is composed of peers directly controlled by end-users. Thus, router nodes in a diffusion network are not static as in IP multicast routing. Their departure induces a non-desired pruning of a sub-tree or disruption of stream to the dependent peers, requiring the affected nodes to rejoin which incur overhead and delays.

User behavior also contributes to the bandwidth dynamics since a user may run multiple applications at the same time due to which the variations in available bandwidth may degrade streaming quality to itself or other depending peers.

Current relevant solutions either focus on stability of nodes [24] or bandwidth [25]. If stability is correlated to user behavior, bandwidth too is impacted by it and therefore needs to be addressed.

3.2 Resource share

In a P2P network, to provide a good level of performance, peers must effectively act both as client and server. In ALM proposals, due to the protocol itself or selfish behavior, this condition is not always satisfied. Solutions to unfair protocols are addressed by splitting the whole content into chunks and diffusing them on different peers. Thus for a content part, each peer hosting a chunk will act as a root node in the tree [20]. Concerning selfish nodes, incentive approaches are proposed to make them participate actively. The general principle they rely on consists in providing peers with a QoS related to its level of contribution [5, 29]. Again these approaches are in isolation and considering them along with other aspects such as user behavior is challenging but needed.

3.3 Network constraints

Since ALM approach builds a virtual network over the physical one, these two are not always well matched. Consequently, users in the same network may have multiple connections outside the network forcing the ISPs to forward the same traffic multiple times. This has not only created issues for ISPs but it also leads to performance limits due to long physical distances between peers. Current improvements consist in having an overlay topology which matches the underlying physical one [3]. However, incorporating these approaches in real systems is not trivial because if an algorithm chooses a stable node as a stream provider, it must not necessarily exist in the same network. How to tradeoff between the two and to find the optimal solution is an issue to deal with.

4 PRINCIPLES AND CHALLENGES FOR AN AGENT-BASED SOLUTION

As discussed in section 3, there are several performance issues in currently deployed ALM infrastructures and solutions exist for most of them individually. The results of current solutions are convincing and the approaches are valid. Nonetheless, the sole consideration of one parameter among others is not sufficient to provide a fully-operational infrastructure able to efficiently deal with QoS as a whole. Indeed, all these parameters should be put together to provide such a solution. Using a formal approach from which a dedicated algorithm could be deduced is not possible for two reasons. Firstly, there is no optimal solution in which all the performance parameters could be maximized. Secondly, if such a solution exists, the algorithm intended to reach it would present too high a complexity. This is why the solution we propose consists in keeping ALM protocols and algorithms unchanged but adding an additional component able to deal with all of these parameters and provide a consensual solution. The straightforward element which could provide such functionality is an agent evolving in a multi-agent system (MAS) [28].

4.1 Use of Multi-agent System in ALM infrastructure

We do not propose a new model of MAS; instead we want to utilize the existing agent's techniques by combining them with the P2P system. We discuss how to use these models in the present case and what are the problems induced. An agent is a physical or virtual entity able to (1) follow a goal, (2) perceive its environment, (3) communicate with other agents, (4) perform actions on itself and its environment and (5) manipulate reasoning systems [26, 30]. We want to integrate an agent in each peer which can perform these functionalities in an asynchronous and concurrent way. The concept of integrating an agent into peers is shown in Figure 1.

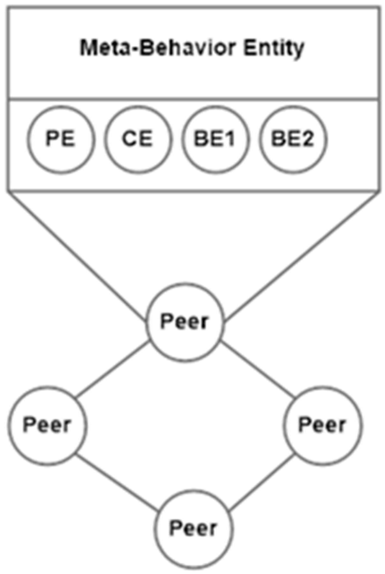

Fig. 1. Abstract structure of an agent integrated into a peer

The agent part can contain a perception entity (PE), a communication entity (CE), several behavior entities (BEs) and a meta-behavior entity. PE is responsible for all the interactions between the agent and its virtual environment. The environment consists of information from the network and the P2P infrastructure. Similarly CE manages the information exchanges between agents. Behavior entity (BE) is in charge of dealing with one aspect of the problem such as dynamic of user presence, resource share, latency and bandwidth. It has to propose an adapted answer to the request of the meta-behavior entity also called control mechanism according to the goal of the agent. The control mechanism is responsible for managing various activities according to its internal state and its environment.

4.2 Challenges

We presented the general concept we want to use for integrating agents into P2P architecture. From this point several related questions remain open which give rise to the following challenges.

4.2.1 Challenges for Behavior Entities

A behavior entity can be responsible for estimating the quality level of one performance aspect. For example the behavior entity in charge of the user's dynamic modeling anticipates the future behavior of a user. It analyzes data coming from logs describing user's actions like joining the group, receiving data, transmitting data and leaving the group. These activities represent different aspects of user's behavior for example online time, contribution, etc. One challenge for this behavior entity is the mechanism it should adopt to classify this data and utilize it for predicting the user's future behavior. For example, should it use a statistical estimation model, a machine learning algorithm or a rule based system to utilize the logs' data? Another challenging aspect for a behavior entity concerns control actions. Once a performance limit is identified (e.g., the presence of an unstable node as parent node), we need to define the way the agent will act. We identified two different strategies. The first consists in solely using primitives of the ALM protocol which are generally: join, leave, and maintenance, through which a node can leave its current location and can rejoin at a new location. The second consists in circumventing the protocol and proposing new possible actions. One example is the exchange of two nodes' positions in the overlay.

4.2.2 Challenges for the Meta-Behavior Entity

This entity stands for the core of the agent and is the most challenging one. According to the application requirements, it is responsible for dynamically switching from one behavior to another. It evaluates the criticality of each performance parameter such as latency, bandwidth, and dynamics of user's presence, computed by the behavior entities and decides which behavior can improve the performance. Then it requests the corresponding behavior entity to take an appropri-ate action according to the QoS requirement. This can be achieved by several methods, from a basic algorithm in the case of a reactive agent to a more evolved solution, based for example on an automate in the case of an agent having several behavior entities [27]. Normalizing the perception of each performance parameter is not trivial since these parameters are of different nature and obtained through different processes such as learning, instrumentation and collaboration. We need a mechanism able to manage all these parameters in an integrated way.

4.2.3 Challenges for the whole community

Since agents operate in an independent and concurrent way, behaviors they adopt will be different according to the space and time. The question of algorithms convergence has to be addressed. It concerns two aspects. The first concerns the difference, at a given time of instantia-teed behaviors. Is it possible for a community to have different agents trying to optimize a different performance parameter? Should we use a coordination entity? Should agents define dynamic zones in which the same behavior is instantiated? The second aspect of the convergence challenge concerns the possibility for an agent to perform actions on remote ones, e.g. actions required by a node swap operation. Such a possibility makes the convergence of the overlay toward a stable state non-trivial. For example, if a node swap operation improves the QoS of two nodes, as a side effect, it can reduce the QoS of other neighboring nodes.

Currently, we are working to answer these questions. We are starting from the BE. Right now, we are investigating and comparing different approaches to utilize one of them in BE for understanding and predicting the user behavior in a decentralized way.

5 CONCLUSION AND FUTURE WORK

Due to persisting problems in the deployment of IP multicast, peer-to-peer application layer multicast has emerged as an alternative mechanism for group communication. ALM has faced the QoS problems due to user dynamics, resource sharing, delay and geographic distance between the peers. Several proposals have come, each of which deals with one of these parameters but none of them provides a global solution, considering user dynamics, resource sharing, delay and geographic distance simultaneously. If a system is optimized for resource sharing only, then the QoS problem still exists due to user dynamics or delay. To come up with a global solution, one has to address all of them. These parameters differ from each other in nature and we need a comprehensive mechanism to deal them all at the same time. Our proposal is based on MAS which integrates an agent in each peer. MAS are ideal systems to represent problems having multiple resolution methods, multiple prospects and multiple solvers. The contribution of this paper is the identification of challenges in integrating MAS into P2P infrastructure to give global solution addressing QoS. The challenges we identify are firstly, choosing the mechanism for estimating a performance parameter. Secondly, normalizing the perception of each performance parameter which is collected through different processes. Thirdly, the algorithm convergence in the entire community and the possibility of agents' actions on each other are questions to be answered. Currently, we are working on the design of a behavior entity intended to understand the user's behavior. We are investigating a statistical estimation model, a rule-based model and several machine learning algorithms to compare them and choose the one that is the most adapted to the P2P ALM environment.

6 REFERENCES

[1] Cisco, “White paper: Cisco visual networking index: Forecast and methodology, 2014–2019,” Cisco, Tech. Rep., May 2015.

[2] I. Ullah, G. Doyen, G. Bonnet, and D. Gaiti, “A survey and synthesis of user behavior measurements in video streaming systems,” IEEE Communications Surveys & Tutorials, vol. 14, no. 3, pp. 734–749, 2012.

[3] J. Zhao and J. Lu, “Solving overlay mismatching of unstructured p2p networks using physical locality information,” in Proceedings of the 6th International Conference on P2P Computing – P2P’06. IEEE, 2006.

[4] I. Ullah, G. Doyen, G. Bonnet, and D. Gaiti, “User behavior anticipation in P2P live video streaming systems through a Bayesian network,” in 12th IFIP/IEEE International Symposium on Integrated Network Management (IM). IEEE, 2011, pp. 337–344.

[5] K. Park, S. Packy, and T. Kwon, “Climber: An incentive-based resilient peer-to-peer system for live streaming services,” in Proceedings of the 7th International Workshop on Peer-to-Peer Systems – IPTPS’08, 2008.

[6] Y. Chu, S. G. Rao, S. Seshan, and H. Zhang, “A case for end system multicast,”, IEEE Journal on Selected Areas in Communications, vol. 20, no. 8, pp. 1456–1471, 2002.

[7] M. Bawa, H. Deshpande, and H. Garcia Molina, “Transience of peers & streaming media,” SIGCOMM Comput. Commun. Rev., vol. 33, no. 1, pp. 107–112, 2003.

[8] X. Zhang, J. Liu, B. Li, and T.-S. P. Yum, “CoolStreaming/DONet: A data-driven overlay network for Peer-to-Peer live media streaming,” in IEEE INFOCOM, 2005, pp. 2102–2111.

[9] N. Magharei and R. Rejaie, “PRIME: Peer-to-Peer Receiver-drIven MEsh-based streaming,” in IEEE INFOCOM, 2007, pp. 1415–1423.

[10] K. Pal, M. Govil, and M. Ahmed, “A new hybrid approach for overlay construction in p2p live streaming,” in International Conference on Advances in Computing, Communications and Informatics (ICACCI), 2015, pp. 431–437.

[11] F. Wang, Y. Xiong, and J. Liu, “mTreebone: A collaborative tree-mesh overlay network for multicast video streaming,” IEEE Transactions

on Parallel and Distributed Systems, vol. 21, pp. 379–392, 2010.
[12] S. Xie, B. Li, G. Y. Keung, and X. Zhang, “Coolstreaming: Design, Theory, and Practice,” IEEE Transactions on Multimedia, vol. 9, no. 8, pp. 1661–1671, 2007.
[13] Z. Li, G. Xie, M. A. Kaafar, and K. Salamatian, “User behavior characterization of a large-scale mobile live streaming system,” in Proceedings of the 24th International Conference on World Wide Web, ser. WWW ’15 Companion, 2015, pp. 307–313.
[14] I. Ullah, G. Bonnet, G. Doyen, and D. Gaiti, “Improving performance of ALM systems with Bayesian estimation of peers dynamics,” in 12th IFIP/IEEE International Conference on Management of Multimedia and Mobile Networks and Services (MMNS), 2009, pp. 157–169.
[15] Z. Liu, C. Wu, B. Li, and S. Zhao, “Distilling superior peers in large-scale P2P streaming systems,” in IEEE INFOCOM, 2009, pp. 82–90.
[16] F. Wang, J. Liu, and Y. Xiong, “Stable peers: Existence, importance, and application in Peer-to-Peer live video streaming,” in IEEE INFOCOM, 2008, pp. 1364–1372.
[17] S. Horovitz and D. Dolev, “Collabrium: Active traffic pattern prediction for boosting P2P collaboration,” in IEEE International Workshops on Enabling Technologies, 2009, pp. 116–121.
[18] I. Ullah, G. Bonnet, G. Doyen, and D. Gaiti, “Modeling user behavior in P2P live video streaming systems through a Bayesian network,” in IFIP International Conference on Autonomous Infrastructure Management and Security (AIMS), 2010, pp. 2–13.
[19] I. Ullah, G. Doyen, G. Bonnet, and D. Gaiti, “An autonomous topology management framework for QoS enabled P2P video streaming systems,” in International Conference on Network and Service Management (CNSM). IEEE, 2012, pp. 126-134.
[20] V. Venkat, V. Venkataraman, P. Francis, and J. Calandrinoz, “Chunkyspread: Multi-tree unstructured peer-to-peer multicast,” in Proceedings of the 5th International Workshop on Peer-to-Peer Systems – IPTPS’06, 2006.
[21] M. Sayit, S. Demirci, Y. Kaymak, and E. Tunali, “Adaptive, incentive and scalable dynamic tree overlay for p2p live video streaming,” Peer-to-Peer Networking and Applications, pp. 1–15, 2015.
[22] N. Magharei, R. Rejaie, I. Rimac, V. Hilt, and M. Hofmann, “Isp-friendly live p2p streaming,” IEEE/ACM Transactions on Networking,, vol. 22, no. 1, pp. 244–256, 2014.
[23] X. Liao, H. Jin, Y. Liu, L. M. Ni, and D. Deng, “Anysee: peer-to-peer live streaming,” in Proceedings of INFOCOM’06. IEEE, 2006.
[24] A. Koutsopoulos, C. Scheideler, and T. Strothmann, “Towards a universal approach for the finite departure problem in overlay networks,” in Stabilization, Safety, and Security of Distributed Systems, ser. Lecture Notes in Computer Science. Springer International Publishing, 2015, vol. 9212, pp. 201–216.
[25] M. Efthymiopoulou, N. Efthymiopoulos, A. Christakidis, N. Athanasopoulos, S. Denazis, and O. Koufopavlou, “Scalable playback rate control in p2p live streaming systems,” Peer-to-Peer Networking and Applications, pp. 1–15, 2015.
[26] D. Weyns, V. D. Parunak, H., M. Fabien, T. Holvoet, and J. Ferber, “Environments for multiagent systems state-of-the-art and research challenges,” in Environments for Multi-Agent Systems. Springer, 2005, pp. 1–47.
[27] Z. Guessoum, M. Cossentino, and J. Mestras, “A roadmap of agent-oriented software engineering: The european agentlink perspective,” in Methodologies and Software Engineering for Agents Systems. Kluwer Publishing, 2004, pp. 430–450.
[28] A. Ahmed, L. Boulahia, D.Gaiti, “An intelligent agent-based scheme for vertical handover management across heterogeneous networks” in Annals of Telecommunication. Springer, 2011 Vol:66, pp.583–602.
[29] A. Ahmed, L. Boulahia, D.Gaiti, “Enabling Vertical Handover Decisions in Heterogeneous Wireless Networks: A State-of-the-Art and A Classification”, IEEE Communications Surveys & Tutorials, IEEE, Vol. 16, no. 2, 2014.
[30] A. Ahmed, L. Boulahia, D. Gaïti and R. Amoud, “Towards a Knowledge-based Intelligent Handover in Heterogeneous Wireless Networks”, IEEE-Local Computer Networks, pp: 284-287, IEEE, 2010.