An Approach to Peer Selection in Service Overlays

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***Abstract*—Networking services are increasingly being provided by peer-to-peer service overlay networks (P2P SON), allowing service providers to cooperatively offer and run a flexible set of services. In this respect, the selection of peers is a key issue for improving resource usage and end users Quality of Experience (QoE). This paper presents an approach to best peer selection in a three-tier P2P SON architecture, allowing the splitting of service business functions and peer selection functions. The proposed best peer selection approach is evaluated by simulation, using a 5-dimension distance metric available in the literature and real delay, jitter and geographical positioning made available by the CAIDA project and MaxMind's free database. The simulation results show the consistency and good performance of the proposed peer selection approach.**

***Index Terms*—Services management, P2P, Service aggregation**

I. Introduction

Service providers can enhance their ability to make their service or service components available to a broader set of customers, through the utilization of a Service Overlay Network (SON) [1], [2]. In this case, a SON acts as an infrastructure where services are published/offered and to which the users access in order to select and use these services. Moreover, a SON can be created by a consortium of service providers using the Internet to make their services available to the user community at large. One way of constructing that kind of SON is by using the peer-to-peer (P2P) technology. This leads to a self-organizing overlay and, additionally, to sharing maintenance costs among service providers.

Although P2P eases the construction and maintenance of SONs, it does not guarantee adequate service performance. In order to maximize performance, the best peer must be found in the P2P SON, among all the potential partners that provide the desired service. Naturally, the choice of best peer should take into account one or more of a set of Quality of Service (QoS) parameters, such as delay, jitter, available bandwidth, etc.. Nevertheless, to minimize inter-provider traffic and, thus, reduce costs for the user and for the service provider, the choice of peers belonging to a different, remote domain should be avoided as much as possible. Thus, locality should also be taken into consideration when choosing a SON peer.

Previous work from the same authors [3]–[5] proposed an architecture for services management in P2P Service Overlay Networks (SON). The architecture, named OMAN, takes into account several aspects of services management, particularly the use of a second overlay - called Aggregation Service (AgS) - to provide efficient service search in the context of multi-domain P2P SONs. In its turn, this paper deals with the proposal and assessment of a third-tier component of OMAN, whose purpose includes the searching and selection of the best peer with which a service-requesting peer should interact in the context of the P2P SON.

Having in mind the stated goal and approach, this paper is organized as follows. Section II discusses related work and also provides the context of the current work, by briefly presenting the OMAN architecture, which the BPSS component belongs to. Section III describes the proposed BPSS service. Subsequently, Section IV presents and discusses the simulation results, after describing the simulated scenarios. Section V summarizes the contributions and presents further work.

II. Related Work

A. Peer Selection

Haase et. al [6] explores neighboring peers relationships and shared peers expertise in order to select peers. The use of artificial intelligence techniques, like machine learning, is another approach to peer selection, which also takes advantage of the peers' expertise [7]. This latter work aims at adapting the selection process to the peers' requirements.

In file sharing, the free-riding problem encourages the adoption of incentive mechanisms as part of the selection scheme. Thus, the fairness between uploads and downloads is used as a metric to the best peer selection. Bittorrent [8] is an emblematic example for this. However, our scheme does not target file(data)-sharing environments. Rather, the problem is to select the best peer that satisfies the requirements of the intended service. Therefore, in our case, performance instead fairness is used. In addition, unlike file sharing applications, our approach considers the best peer selection process for long lasting sessions, as opposed to relatively short burst chunk downloads/uploads.

Furthermore, P2P traffic is an issue faced by ISPs and over the Internet in general. In order to assist ISPs in avoiding costs with the choice of best peers out of their own domains, several proposals have been put forward [9], [10]. These advocate the collaboration between providers and P2P applications. On the other hand, our BPSS scheme selects best peers for service interactions inside the geographical domain of the service requester, without the need for explicit collaboration between the service providers.

B. OMAN

OMAN is a P2P SON architecture that handles aspects ranging from the composition of the SON until the interaction aspects between the services and the SON, including how to take advantage of the information at the P2P overlay level to leverage the services and applications. Fig. 1 provides an overview of the OMAN architecture.

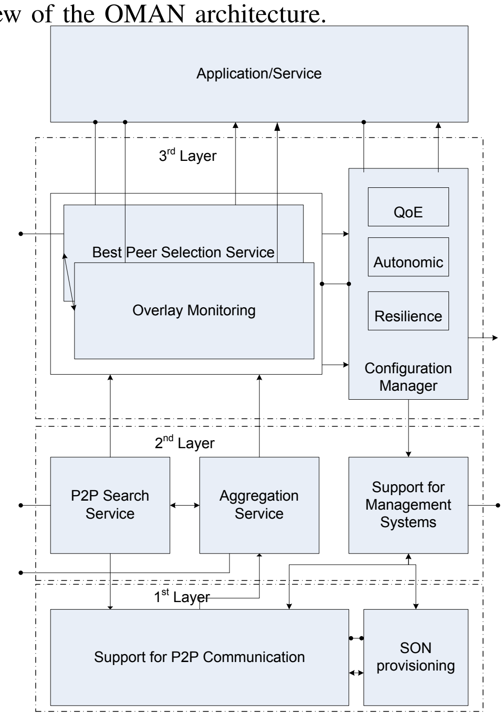

Fig. 1. The OMAN architecture [4]

The lower layer of the architecture is the basic P2P SON layer. The central module of the second tier of OMAN is the Aggregation Service (AgS) [3], [5]. AgS is an unstructured P2P overlay-tier, meaning there is no tight coupling between overlay topology and information location/placement. AgS executes on top of the P2P SON and it consists of peers that belong to potential providers interested in advertising/offering their services. The purpose of AgS is to aggregate the offerings of services and service components. This is accomplished by concentrating the service offerings in its peers (nodes), in order to facilitate and optimize the services searching process.

The peers that form the AgS P2P overlay are called *aggregation peers (AgS peers)*. They are chosen among the peers that form the underlying P2P SON tier, which makes them specialized *SON peers*.

Searching for a service, using the AgS framework, therefore results in a set of references to SON peers that offer an interface to services matching the search criteria. This preserves the internal details of the service, since the external entity, i.e. a user, a third party service provider, or other SON peer in the P2P SON, is only granted with a mediated access (by means of the SON peer), which may hide sensitive information and filter undesired operations.

The Best Peer Selection Service is one of the modules of the third tier of the OMAN architecture.

III. Best Peer Selection Service

The objective of the Best Peer Selection Service (BPSS) is to provide SON peers with the identification of the best peer for a particular service, in the context of services offering in a P2P SON.

A. BPSS Overview

Regarding the use on OMAN, service developers can implement an interface with the BPSS module in order to request and receive best peer information, allowing the splitting of service business functions and best peer determination. This decoupling enhances modularity and best peer selection metric independence, thus leading to high flexibility when choosing the particular metric to use for a particular service type.

Fig. 2 illustrates the use of BPSS. SON peers can request best peer information (select_BP), regarding a particular service, from the BPSS module. On the reception of a best peer request, the BPSS module asks the AgS service the list of all SON peers that have published a service profile for the intended service. After receiving the requested list, the BPSS module calculates the best peer and returns its reference to the requesting SON peer. The selection of the best peer is done using one of the supported metrics. In sub-section B one of such metrics is presented.

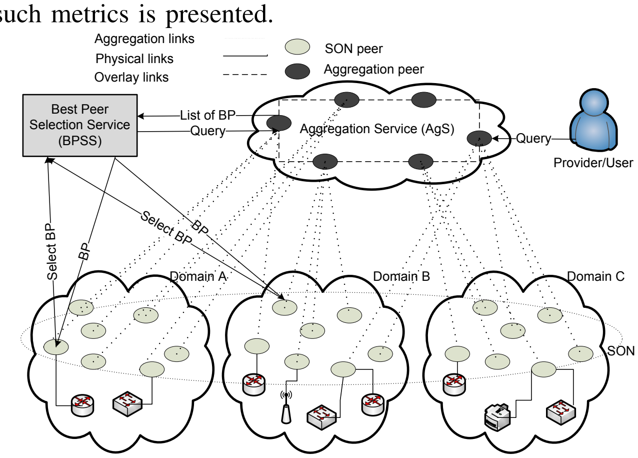

Fig. 2. BPSS Architecture

B. Metrics

The proposed BPSS service is based on one or more service performance metrics to determine best peers. Although BPSS provides independence from the used performance metrics, for the purpose of implementation and evaluation a specific metric was used.

Performance of P2P systems is often very sensitive to the underlying delay characteristics. These are influenced, among other factors, by bandwidth, load and also geographic location. In fact, according to [11], the geographical location of nodes heavily influences jitter and packet loss. This observation points to the need for the node's geographic location when developing a delay prediction model. Having this in mind, the authors of [11] developed a predictive model of the Internet delay space that takes into account the geographical location of the nodes and the delay between them. Using a rich set of real data, namely measured end-to-end round trip time (rtt) [12] and measured end-to-end link jitter [13], those authors mapped the measured end-to-end nodes into a 5-dimensions Euclidean space model of the Internet, by combining this information with global network positioning information [14]. Using the coordinates of each peer in this 5-dimensions model, it is then possible to calculate the Euclidean distance between peers, which takes into account not only network conditions but also peer location.

For the purpose of the work presented in this paper, BPSS used the mentioned distance metric in order to select the best peer for a particular SON peer.

IV. Evaluation

In order to assess the BPSS behavior, we conducted a simulation study to observe the best peer selection distribution over well-constrained geographical domains.

A. Used Simulator

The PeerFactSim.KOM [15] discrete event simulator was used in all simulations.

B. Simulations setup

The simulation environment was constituted of SON peers whose network identifiers (IP addresses) were taken from the CAIDA project and MaxMind GeoIP database. Therefore, the simulated peers belong to real geographical domains. The Internet delay space scheme presented in section III.B was used.

The scenarios were modeled based on real nodes available in the compiled data set. To accomplish that, peers belonging to specific geographical country domains were split between SON and aggregation peers. The number of AgS peers was 10% of the total number of SON peers used in each domain. Thus, if a country had 50 SON peers at the P2P SON - which, for instance, can mean that it comprised 50 service providers - then 5 AgS peers belonging to that country would be part of the Aggregation Service. The chosen geographical domains were the following European countries: Portugal, Spain, France, Italy and Germany.

The simulation comprised 11 sets of individual simulations. Each set simulated a particular number of SON and AgS peers. The initial set simulated a scenario with the total of 50 SON peers, corresponding to 10 randomly chosen SON peers from each of the aforementioned countries. The second simulated set comprised the total of 75 SON peers (15 for each country). Thus, with steps of 25 SON peers between each simulated scenario, the last simulated set comprised 300 SON peers.

C. Simulations strategy

The interaction between the requesting SON peer and the SON peers selected as the best and the second-best peer was also evaluated. The second-best peer is selected from the same list of SON peers provided by the AgS service, by removing the best peer from that list and repeating the measurement process.

The determination of the second-best peer can aid in the validation of the used metric in two ways: 1) by checking if the service behaves better with the selected best peer, this provides a measure of the metrics consistency; 2) by measuring the average improvement of the best peer over the second-best peer, an indication of the metrics effectiveness can be obtained.

The wide range of simulated P2P SON sizes intends to cover scenarios with few service providers (e.g. small P2P SON for very specialized services) until scenarios composed of many service providers (e.g. a more competitive scenario).

D. Results

The results presented in this section show the distribution of best and second-best peers regarding requests made by SON peers belonging to the Portuguese geographical domain only, though it is obvious that the used methodology can be applied to any other geographical domain.

Fig. 3 depicts the geographical location of the SON peers selected as best peers. There are eleven 5-bar clusters, each one corresponding to one of the eleven simulated scenarios. In each cluster, each of the five bars represents the number of best peer occurrences in each of the five geographical domains, namely Portugal, Spain, France, Italy, and Germany, respectively.

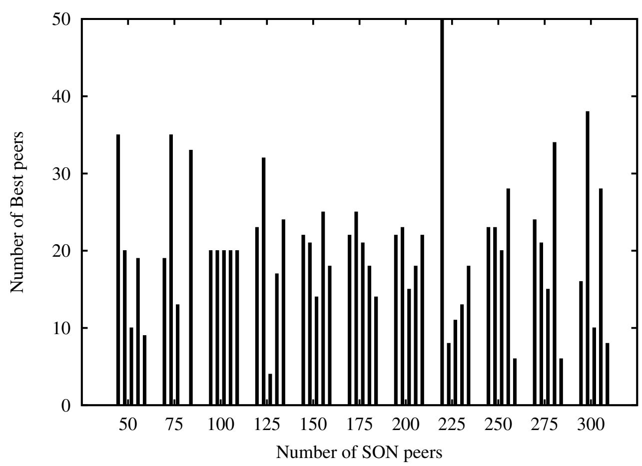

Fig. 3. BPSS Architecture

One can expect the highest number of selected best peers is in the domain of the requester (Portugal, in the case of these simulations), due to geographical distance considerations. Nevertheless, the obtained results clearly show the effect of two key aspects of the OMAN architecture and of its AgS and BPSS services: on one side, in some cases, service searching performed by the AgS service determined that the desired services were not available at any of the SON peers of the requester's domain; on the other hand, the metric used by the BPSS service - based on the Internet model proposed in [11], which takes into account not only the geographical position but also delay and jitter - led to the fact that the closest peer, in terms of the 5-dimension Euclidean distance, resided in a different domain.

Nevertheless, even with the mentioned constraints regarding the statistical availability (or unavailability) of the desired services in the requester's domain, averaging the results of all simulations shows that the highest number of best peers was selected in the same domain of the requester. This can be seen in Fig. 4 and Fig. 5.

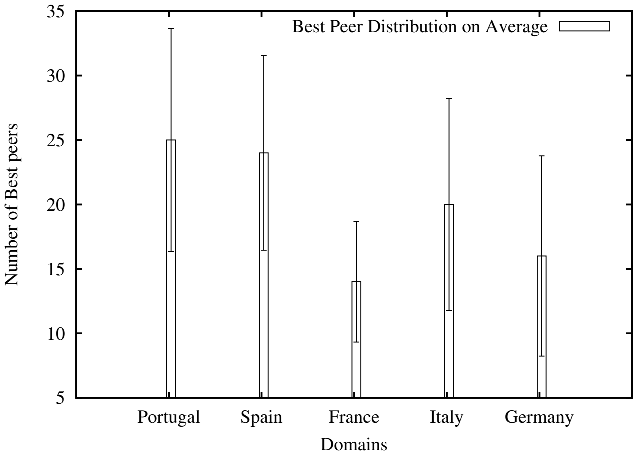

Fig. 4. BPSS Architecture

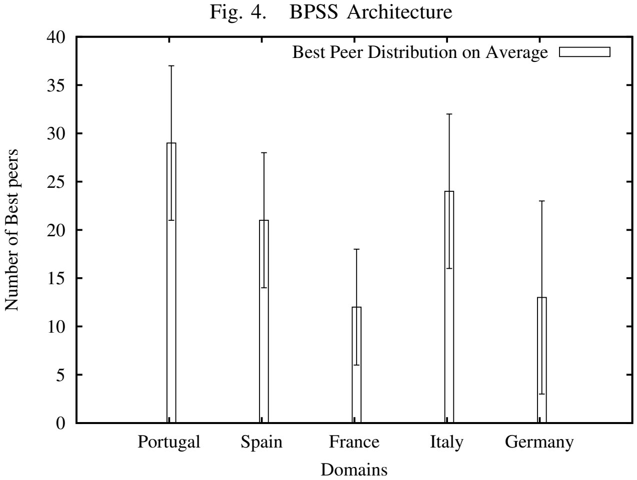

Fig. 5. BPSS Architecture

Taking the sum of best peers and second-best peers by domain, SON peers in the requester's domain (Portugal) were selected as best peers in 27% of the time, followed by Spain (22.5%), Italy (22%), Germany (14.5%) and France (13%). This means that almost half the best peer selections resulted in peers belonging to the same geographical domain or to the neighboring geographical domain. This suggests the consistency of the used metric and the good operation of OMAN's AgS and BPSS services.

V. Conclusion

In this paper, an approach to the problem of best peer selection in peer-to-peer service overlay networks has been proposed and studied. The main features of the presented BPSS are the use of a very efficient aggregation service (AgS) for service searching, and its independence from the best peer selection metric. The latter feature provides flexibility, adaptability and modularity to the overall process of best peer selection.

The performed simulations involved the selection of best and second-best peers in a universe of five distinct geographical domains. Obtained results have shown that BPSS performs well and that the overall OMAN architecture - of which the AgS service is a key component - is very effective.

Further work can compare different best peer selection metrics, based not only on different performance parameters, but also on factors such as inter-provider link cost. Still another line of research can be the use of the OMAN approach by service providers in order to identify ways of maximizing user quality of experience or ways of reducing inter-provider traffic, e.g., by deploying specific peers inside their own domain.

References

[1] C. Tran and Z. Dziong, "Service overlay network capacity adaptation for profit maximization," *IEEE Transactions on Network and Service Management*, vol. 7, no. 2, pp. 72–82, Jun. 2010.

[2] S. Zhou, M. Hogan, S. Ardon, M. Portman, T. Hu, K. Wongrujira, and A. Seneviratne, "ALASA: when service overlay networks meet peer-to-peer networks," in *Communications, 2005 Asia-Pacific Conference on*, Perth, WA, USA, 2005, pp. 1053–1057.

[3] A. Fiorese, P. Simões, and F. Boavida, "Service searching based on P2P aggregation," in *Proceedings of International Conference on Information Networking 2010 (ICOIN 2010)*, Busan - South Korea, 2010.

[4] ——, "OMAN – a management architecture for P2P service overlay networks," in *Mechanisms for Autonomous Management of Networks and Services*, ser. Lecture Notes in Computer Science, vol. 6155. Zurich, Switzerland: Stiller, Burkhard; De Turck, Filip, Jun. 2010, pp. 14–25.

[5] ——, "An aggregation scheme for the optimisation of service search in Peer-to-Peer overlays," in *Network and Service Management (CNSM), 2010 International Conference on*, Niagara Falls, Canada, Oct. 2010, pp. 481–486.

[6] P. Haase, R. Siebes, and F. Harmelen, "Expertise-based peer selection in Peer-to-Peer networks," *Knowledge and Information Systems*, vol. 15, no. 1, pp. 75–107, Jan. 2007.

[7] D. S. Bernstein, Z. Feng, B. N. Levine, and S. Zilberstein, "Adaptive peer selection," in *In Proceedings of the 2nd International workshop on Peer-toPeer Sustems (IPTPS03)*, 2003.

[8] K. Huang, L. Wang, D. Zhang, and Y. Liu, "Optimizing the BitTorrent performance using an adaptive peer selection strategy," *Future Generation Computer Systems*, vol. 24, pp. 621–630, jul 2008.

[9] V. Aggarwal, O. Akonjang, and A. Feldmann, "Improving user and ISP experience through ISP-aided P2P locality," in *INFOCOM Workshops 2008, IEEE*, 2008, pp. 1–6.

[10] H. Zhuang, Y. Xu, Y. Hu, and X. Lin, "A peer selection mechanism in P2P networks based on the collaboration of ISPs and P2P systems," in *Information Science and Engineering, International Conference on*, vol. 0. Los Alamitos, CA, USA: IEEE Computer Society, 2009, pp. 1573–1576.

[11] S. Kaune, K. Pussep, C. Leng, A. Kovacevic, G. Tyson, and R. Steinmetz, "Modelling the internet delay space based on geographical locations," in *Parallel, Distributed and Network-based Processing, 2009 17th Euromicro International Conference on*, 2009, pp. 301–310.

[12] "Macroscopic topology measurements," http://www.caida.org/projects/macroscopic/.

[13] "The PingER project," http://www-iepm.slac.stanford.edu/pinger/.

[14] S. Lee, Z. Zhang, S. Sahu, and D. Saha, "On suitability of euclidean embedding of internet hosts," in *ACM SIGMETRICS Performance Evaluation Review*, vol. 34. New York, NY, USA: ACM, Jun. 2006, pp. 157–168.

[15] A. Kovacevic, S. Kaune, N. Liebau, R. Steinmetz, and P. Mukherjee, "Benchmarking platform for peer-to-peer systems," *it - Information Technology*, vol. 49, no. 5, pp. 312–319, Sep. 2007.