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NETWORK OSILLATION AND ANALYSIS OF ONLINE COMMUNICATION WITH MULTI SINK NETWORK PATHS

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ABSTRACT

Computing the average shortest-path length of a large scale-free network needs much memory space and computation time. Hence, parallel computing must be applied. In order to solve the load-balancing problem for coarse-grained parallelization, the relationship between the computing time of a single-source shortest-path length of node and the features of node is studied. We present a dynamic programming model using the average out degree of neighbouring nodes of different levels as the variable and the minimum time difference as the target. The coefficients are determined on time measurable networks. A native array and multi map representation of network are presented to reduce the memory consumption of the network such that large networks can still be loaded into the memory of each computing core. The simplified load-balancing model is applied on a network of tens of millions of nodes. Our experiment shows that this model can solve the load-imbalance problem of large scale-free network very well. Also, the characteristic of this model can meet the requirements of networks with ever-increasing complexity and scale.

1. INTRODUCTION

All-pairs shortest-path length is the sum of single-source shortest-path length (SSSPL) of each node in, There are two types of parallel methods to compute all-pairs shortest-path length, the fine-grained parallelization method and the coarse-grained parallelization method. In fine-grained parallelization, the computing of the SSSPL for each node is accomplished using multiple cores to reduce the computing time. Therefore, the time needed in getting the sum of the SSSPL of every node can be reduced as well. While in coarse-grained parallelization, suppose that there are nodes in and cores available for computing; then one core is responsible for the computing of the SSSPL of nodes. This kind of parallelization will not reduce the time needed in computing the SSSPL of one node, but ideally, the time needed in computing the all-pairs shortest-path length can be reduced to of that of a serial algorithm.

Compared with fine-grained parallelization, coarse-grained parallelization is much easier to implement on most parallel computers, because only a reduction operation is needed after all cores have finished their assignments of computing the SSSPL of their respective nodes. In fine-grained parallelization, apart from a reduction operation in the end, a lot of scheduling and communication operations will be needed in computing the SSSPL of each node. These operations will decrease the performance of parallelization, as there are more and more computing nodes available to us, and the complexity and scale of networks are ever increasing. For any realistic scenario, the number of nodes in large scale-free networks will be significantly larger than the number of cores used by the parallel algorithm. Therefore, the coarse-grained method is also efficient because no computing resources are wasted.

2. RELATED WORK

Scale-free topology models were introduced to catch the logical relationships among entities belonging to a complex and interconnected system. Today, they are widely adopted in biological, social, economic, and technology application fields to describe, for instance, cellular metabolism mechanisms [1], neural networks [2], epidemic phenomena [3], connections among scientific coauthors [4], online social network [5], stocks and shareholders relationships [6], web graphs [7], and network architectures (e.g., autonomous system and overlay nodes [8]). In this context, the shortest path length represents an extremely important parameter, useful to predict the behavior and the performance of the considered interconnected system (think, for example, to the disease spread in a network of people [3], or to the communication latencies in Internet-like topologies [9], and so on). Unfortunately, quite a few contributions investigated the shortest path length between node pairs and the diameter, defined as the maximum distance between any node pair in the topologies. For instance, the distribution of the average shortest path over different topologies has been studied in [7], but the terms "average shortest-path length" and "diameter" have been used as synonyms, Manuscript received February 14, 2017; revised November 30, 2017 and February 21, 2018; accepted April 1, 2018. This work was supported in part by the research project E-SHELF (by the Apulia Region—Italy, code: OSW3NO1). *(Corresponding author: Giuseppe Piro.)* which is not the case. This misunderstanding is recurring in the literature: for instance, in [10], the average shortest path length in scale-free networks has been analyzed by referring it as diameter and specifying that it follows a linear distribution (without estimating the coefficient values). Similar considerations apply also to [11]. In [12], several models were investigated, showing that it is possible to catch the distribution of shortest path lengths by properly tuning the parameters of Gamma, Log-normal, and Weibull probability density functions. The main limitation of these approaches is that there is no explicit way to set their parameters. On the contrary, a *case by case* tuning is required: for each scenario of interest, a specific optimal set of parameters has to be used.

3. PROPOSED METHODOLOGY

Novel Gaussian-based models are proposed hereby, whose parameters can be immediately tuned based on the number of nodes (N) composing the network, only. In this way, given N, it becomes possible to predict the distribution of shortest paths without retuning the model for each scenario of interest. The outcomes of the proposed models have been successfully validated and compared with respect to state-of-the art approaches in a wide set of network topologies. To provide a further insight, the conceived Gaussian-based models have been also evaluated for real Internet topologies, learned from reference data sets. Obtained results highlight that the proposed models are able to reach a good tradeoff between the level of accuracy and complexity, even for real network configurations.

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4. ANALYSIS OF THE MODEL

From the analysis of these two networks, we get two results. First, when the average degree of a network (the number of edges divided by the number of nodes) is large, the time difference is relatively small. Second, when the number of cores is small, the difference is also very small. For example, the difference is 0 when 2 cores are used. The difference will be larger when more cores are used. The first characteristic of this model can meet the demands of the ever-increasing complexity of the network, because the network is becoming more and more complex, and the average degree is getting bigger and bigger. For example, the average degree of the edu04 network is only about 1.5. But in 2008, it has grown into a network with 2,508,811 nodes and 25,278,346 edges and the average degree reaches nearly 10. For the second characteristic, we did experiments on networks of various sizes and found out that the real cause is the decrease of the number of nodes assigned to each core when more cores are used. In other words, for a fixed number of cores, the difference will become smaller when the network is getting larger. We know that the network is growing very fast. Therefore, this characteristic of the model can meet the requirements of the ever-increasing scale of networks.

We also use this load-balancing model on other scale-free networks of various sizes. These networks are generated using BA model with different parameters. We find out that when the ratio of the number of nodes over the number of cores is getting larger, the coefficients are not unique to get the acceptable time difference values, but in every scenario, the difference to the best is very small. For example, when 16 cores are used in a network with 500,000 nodes and 1,500,000 edges, being 31,250, there are 2 combinations of coefficients to get similar minimum time difference values; when 8 cores are used in this network, being 62,500, there will be 3 combinations of coefficients to get similar minimum values. The time difference values related to different numbers of cores and coefficients. We can see that the coefficients of 0.6, 0.3, and 0.1 might not be the best, but they can still be safely used when the ratio is getting bigger. Similar situations can be found in other networks with different parameters.

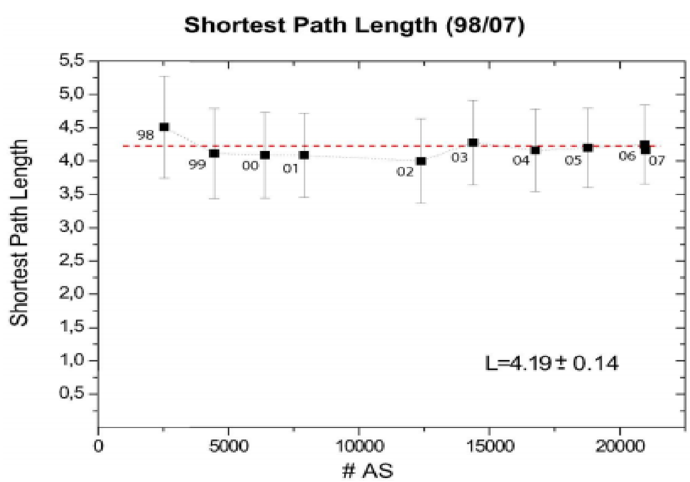

Fig 1 Shortest Path Length L behavior for the network of connections of the Internet Autonomous Systems

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Adaptive modulation and coding (AMC) is used to handle the interference. It present a framework of AMC at PHY layer, link layer scheduling, and network layer routing for a multi-hop wireless network. Throughput rigorous mathematical development, I characterized an optimization framework through a set of constraints across the PHY, link, and network layers. There are two key benefits associated with AMC, namely, concurrent receptions from multiple transmitters and interference rejection. In existing system concurrent transmissions to the same receiver will lead to a collision and are considered wasteful of resource. An AMC receiver is capable of receiving from multiple transmitters at the same time. The ability to decode multiple received signals can also help the receiving node to reject interference from unintended transmitters.

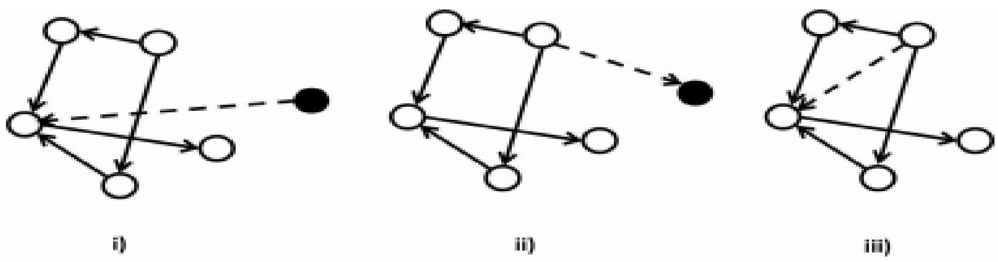

Fig: 2 Growth process in the model: (i) node creation attaching an old node; (ii) node creation as the target of an old node; (iii) link creation.

CONCLUSION

To the best of the authors' knowledge, this paper demonstrates, for the first time, that it is possible to create simple and effective Gaussian based models of the shortest path distribution in scale-free network topologies by accounting for the number of nodes only. The accuracy of the proposed models has been further investigated by considering real Internet network topologies, learned from reference data sets. This work represents a strong advancement of the state of the art because currently available approaches require a case-by-case fitting to catch the properties of the network scenario of interest. For future works, I plan to apply this approach to other distributions, such as Weibull, in order to achieve even better accuracy.

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