Finding Shortest Path in Routing Problem by Using Ant Colony Optimization

Hisham S. Alshaheen
College of Science/ University of Thi-Qar

Abstract

This paper presents an ant colony optimization approach to find the shortest path (SP) in the routing problem. The algorithm is used two different metrics (bandwidth and routing delay) to determine the optimal route path(best route). The proposed method is used to determine the optimal path from source to destination. Ant colony decision must be made under network current conditions, that Minimize delay and Maximum Bandwidth for each link (determine average of all links) to selected optimal link. This paper shows that the proposed algorithms exhibits a much better route optimality from source to destination.

Key words: Ant Colony Optimization; Routing algorithm; Minimum delay; Maximum Bandwidth and optimal path

Introduction

Routing is, the act of moving information across an Internet work from a source to a destination is one of the major issues in computer network literature. Recently nature inspired algorithms have been explored as means of finding an efficient solution to this routing problem. Ant colony optimization (ACO) is a probabilistic technique used for solving complex computational problems, such as finding optimal routes in networks[1].

The idea of using ant colony algorithm is to finding an optimal path in a graph, based on the performance of ants looking for a path between their colony and a source of food , also by having something simple as ants to find a solution for complex computation problems seemed interesting, These new techniques can be used to reduce time consumption to solve telecommunication optimization problems[2].

ACO(ant colony optimization) [1,3] is an algorithm based on the behavior of the real ants in finding a shortest path from a source to the food [1].Ant colony to determine the optimal path from source to destination .In order to make better use of ACO, this paper proposes routing ant colony optimization to select optimal path depend on a minimum delay(delay form source to destination) and maximum bandwidth(for each link) for solving routing problem.

Ant Colony Optimization(ACO)

The algorithm utilizes the behavior of the real ants while searching for the food. It has been observed that the ants deposit a certain amount of pheromone(Pheromone is a chemicals article of acting exterior the body of ants of the secreting individual to manipulate the manners of ants. Pheromone is similar in somehow to common memory[2]) in its path while traveling from its nest to the food. Again while returning, the ants are subjected to follow the same path marked by the pheromone deposit and again deposit the pheromone in its path. In this way the ants following the shorter path are expected to return earlier and hence increase the amount of pheromone deposit in its path at a faster rate than the ants following a longer path. ACO takes the inspiration from the foraging behavior of the ants. These ants deposit pheromone on the ground in order to mark some favorable path that should be followed by other members of the colony.[1]

Ant colony optimization (ACO), on the other hand, is a well-known optimization algorithm that can solve very complicated optimization problem [4]. The ant colony algorithm aims to look for an optimal path in a graph, based on the behavior of ants seeking a path between their colony and a source of food. Thus, ants spread pheromone while they are walking and searching the food. This pheromone helps to find back road towards their nest. An ant can decide from which path should go next when it reaches a crossroad by sensing the pheromone. However, are associated randomly with paths and might varied dynamically when ants searching food[2].

The ant colony optimization technique (ACO) is a heuristic algorithm for solving a number of computational problems by finding solutions through graphs. The original algorithm was proposed to find for an optimal path in a graph based on idea of ant searching a path between their colony and a source of food, from here the ACO name came. The idea is then extended to solve a wider class of numerical problems[5].

Ant Colony Optimization(ACO) in network routing

ACO algorithms can be applied in the network routing problems to find the shortest path [6]. In a network routing problem, a set of artificial ants (packets) are simulated from a source to the destination. The forward ants [3] are selecting the next node randomly for the first time taking the information from the routing table and the ants who are successful in reaching the destination are updating the pheromone deposit at the edges visited by them.[1].

In ACO the paths from a source to a destination are explored independently and in parallel. As soon as an ant arrives at a node, the corresponding pheromone value for a path is updated; hence, each entry of the pheromone table in a node can be updated independently[1].

Routing in ACO is accomplished by sending ants rather than routing tables in traditional routing protocols [7]. In addition, in contrast to traditional routing protocols where the routing control information and data information are exchanged and sent separately using different channels, with ACO routing control and data information can be carried in data packets [8,9].

General characteristics of ACO for routing

The following set of core properties characterizes ACO instances for routing problems[1]: 1. Provide traffic-adaptive and multipath routing.; 2. Rely on both passive and active information monitoring and gathering.; 3. Make use of stochastic components.; 4. Do not allow local estimates to have global impact.; 5. Set up paths in a less selfish way than in pure shortest path schemes favoring load balancing.; 6. Show limited sensitivity to parameter settings.

These are all characteristics that directly result from the application of the ACO's design guidelines, and in particular from the use of controlled random experiments (the ants) that are repeatedly generated in order to actively gather useful non-local information about the characteristics of the solution set (i.e., the set of paths connecting all pairs of source-destination nodes, in the routing case). In turn, this information is used to set and continually update the decision (routing) policies at the decision nodes in the form of pheromone tables. All the other properties derive in some sense from this basic behavior[1].

Proposed algorithm for routing problem:

The proposed approach based on ant colony is used to solve the routing problem. Ant colony decision must be made under network current conditions, that minimum delay and maximum bandwidth (average of all links) to selected optimal link. In this way both minimum delay and maximum bandwidth of paths used by the actual status of the network, providing an optimized network response. The computer network which is considered in this work is modeled as graph shown in Figure(1.1). The imposing values of minimum delay(m sec) and maximum bandwidth (Kbps) in the Table(1.1)

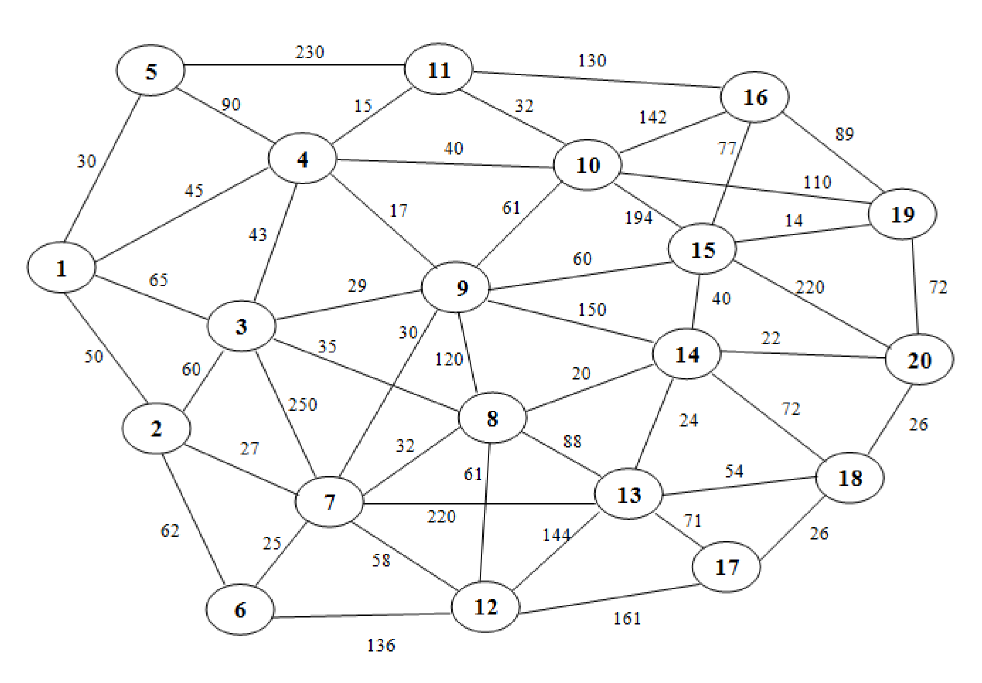

Figure (1.1) Computer network of 20 nodes

Table(1.1) link minimum delay and maximum bandwidth of the computer network.

Link	Minimum delay(msec)	Maximum Bandwidth (Kbps)	Link	Minimum delay(msec)	Maximum Bandwidth (Kbps)
1- 2	50	40	8-14	20	140
1-3	65	50	9-10	61	200
1-4	45	70	9-14	150	120
1-5	30	33	9-15	60	180
2-3	60	45	10-11	32	56
2-6	62	60	10-15	194	120
2-7	27	28	10-16	147	202
3-4	43	18	10-19	110	100
3-7	250	130	11-16	130	80
3-8	35	140	12-13	144	120
3-9	29	120	12-17	161	28
4-9	17	32	13-14	24	45
4-10	40	32	13-18	54	265
4-11	15	200	14-15	40	40
5-11	230	75	14-20	22	320
6-7	25	55	15-16	77	67
6-12	136	34	15-19	14	120
7-8	32	78	15-20	220	45
7-9	30	100	16-19	89	10
7-13	220	153	17-18	26	23
8-9	120	42	18-20	16	90
8-12	61	58	19-20	72	120
8-13	88	71			

Description of the algorithm

Step1: As in any ant colony Routing algorithm, paths are implicitly defined by the values of pheromone variables contained in so-called pheromone table playing the role of routing tables. Defines the pheromone variables in terms of the metrics (minimum delay and average of bandwidth of links). This means that the algorithm tries to find paths characterized by minimal delay between S and D, minimal number of hops and average bandwidth links between nodes. The use of such composite pheromone values allows to optimize multiple objectives simultaneously, which can be very important in complex networks (Pheromone metrics used to define path quality).

Step 2: From each network node s agents are launched towards specific destination nodes d at regular intervals and concurrently with the data traffic. These agents moving from their source to destination nodes are called **forward ants**. Each forward ant is a random experiment aimed at collecting and gathering at the nodes non-local information about paths and traffic patterns.

Step 3: The specific task of each forward ant is to search for a minimum delay path and average bandwidth link connecting its source and destination nodes.

Step 4: While moving, the forward ant collects information about the traveling time. Once arrived at destination, the forward ant becomes a backward ant and goes back to its source node by moving along the same path.

Step 5: At each visited node and arriving from neighbor the backward ant updates the local routing information related to each node in the path followed by the forward ant from to d, and related to the choice of as next hop to reach each node.

Step 6: When a source node s starts a communication session with a destination node d, and no pheromone information is available about how to reach d, the node manager needs to gather long range information about possible paths. Therefore, it broadcasts a reactive forward ant.

Step 7: Each forward ant keeps a list of the nodes it has visited. Upon arrival at the destination d, it is converted into a backward ant, which travels back to the source retracing the path. At each intermediate node, coming from neighbor, the ant information is used to update the entry in the pheromone table. The way the entry is updated depends on the minimum delay and average of bandwidth links between nodes used to define pheromone variables.

Step 8: During the course of a communication session, managers at source nodes periodically send out proactive forward ants to update the information about currently used paths and to try to find new and potentially better paths. They follow pheromone and update pheromone tables in the same way as reactive forward ants do.

Step 9: The path setup phase together with the proactive path improvement actions create a mesh of multiple paths between source and destination. Data are forwarded according to a stochastic policy depending onto the pheromone values (minimum delay path average bandwidth link). The forward ant migrates from a node to an adjacent one towards its destination. At each intermediate node, a stochastic decision policy is applied to select the next node to move to.

Results

To evaluated the efficiency of the proposed algorithm that uses ant colony, it has been applied to the example of computer network in the Figure(1.1) and use information in Table(1.1).The implementation has realized in Matlab. As a result to determine a optimal path from source s to destination d. for example in computer network(Figure 1.1), if the node 1 has packet to be sent to destination node 20, the ant colony optimization is determine the optimal path form node 1 to node 20 depend on shown in Table(1.2).

Table(1.2): Result obtain form ant colony to determine the optimal path from node 1 to node 20 for the computer network (figure1.1)

Source	Destination	Multi-path from S to D	No. of nodes	No. of links	Sum(Minimum delay) of links	Average(Maximum Bandwidth) (Kbps) of links from S to D	Optimal path
1	20	1 5 11 16 19 20	6	5	551	111.6	No
1	20	1 4 11 16 19 20	6	5	351	144	No
1	20	1 4 10 16 19 20	6	5	393	86.8	No
1	20	1 4 10 19 20	5	4	267	80.5	No
1	20	1 4 9 10 19 20	6	5	305	104.5	No
1	20	1 4 9 14 20	5	4	145	132.5	No
1	20	1 4 9 15 20	5	4	343	104.4	No
1	20	1 4 3 9 15 20	6	5	397	74.6	No
1	20	1 4 3 7 13 18 20	7	6	407	121	No
1	20	1 4 3 8 14 20	6	5	159	172.8	No
1	20	1 3 8 14 20	5	4	142	206.5	Yes
1	20	1 3 9 14 20	5	4	266	127.5	No

Conclusion

This paper proposed algorithm an ACO to solve the routing problem. The proposed ACO uses the minimum delay and average of bandwidth of links to select optimal path between source and destination .The pheromone table playing the role of routing tables. defines the pheromone variables two metrics (minimum delay and average of bandwidth of links). When information increases about the computer networks such as the congestion level, throughput (data rate) of links, and numbers of hops. These factors help us to select a best optimal path by ACO. The packet sent from any node to another, is traveling through the computer network without any problem in the routing and in any some time.

References

[1]- R.Geetha, and G. Srikanth, "Ant Colony optimization based Routing in various Networking Domains – A Survey ", International Research Journal of Mobile and Wireless Communications, ICICES-2012-SAEC, Chennai, Tamilnadu , Vol 03, Issue 01; January-April 2012.

[2]- Dalia Sabri," Performance Analysis for Network Coding Using Ant Colony Routing", Master of Philosophy , Electronic and Computer Engineering, School of Engineering and Design ,Brunel University ,December 2011.

[3]- M. Dorigo, V. Maniezzo & A. Colorni. "Ant System: Optimization by a Colony of Cooperating Agents ", IEEE Transactions on Systems, Man, and Cybernetics–Part B, 26 : 29–41.1996

[4]- M. Dorigo, E. Bonabeau, and G. Theraulaz, "Ant algorithms and stigmergy", Future Gener. Comput. Syst., vol. 16, no. 8, pp. 851–871, 2000.

[5]- C. Blum, "Ant colony optimization: Introduction trends", Physics of Life Reviews, vol. 2, no. 4,

pp. 353-373, 2005.
[6]- M. Dorigo, E. Bonabeau, and G. Theraulaz, “Ant algorithms and stigmergy,” Future Gener. Comput. Syst., vol. 16, no. 8, pp. 851–871, 2000.
[7]- R. Ahlswede, N. Cai, S.-Y. R. Li and R. W. Yeung, “Network information flow”, IEEE Trans. on Information Theory, vol. 46, pp. 1204-1216, 2000.
[8]- C. Chekuri, C. Fragouli, and E. Soljanin, “On average throughput benefits and alphabet size for network coding”, IEEE Trans. on Information Theory and the IEEE/ACM Trans. on Networking, vol. 52, pp. 2410–2424, 2006.
[9]- Xiao-Min Hu and Jun Zhang," Minimum Cost Multicast Routing Using Ant Colony Optimization Algorithm" Hindawi Publishing Corporation, Mathematical Problems in Engineering, Volume 2013, Article ID 432686, 13 pages, 18 April 2013.
[10]- Gianni A. Di Caro, F. Ducatelle and Luca M. Gambardella," Theory and practice of Ant Colony Optimization for routing in dynamic telecommunications networks" the Complex Coevolution of Information Technology Ecosystems, Idea Group, Hershey, PA, USA, 2008.

إيجاد أفضل طريق للتوجيه باستخدام خوارزمية النملة

هشام شعلان الشاهين
كلية العلوم/ جامعة ذي قار

الخلاصة

في هذا البحث أفترض خوارزمية لإيجاد أقصر طريق في مشكلة التوجيه باستخدام خوارزمية النملة.ففي هذه الخوارزمية استخدمت مقياسين مختلفين هما عرض النطاق الترددي وتأخير التوجيه لتحديد المسار الأمثل (أفضل مسار). الطريقة المقترحة هي مستعمرة النمل لتحديد المسار الأمثل من المصدر إلى الوجهة. يجب أن يتخذ قرار مستعمرة النمل في ضمن ظروف الشبكة الحالية، والتي هي تأخير الأقل والحد الأقصى لعرض النطاق الترددي لكل وصلة (تحديد متوسط جميع وصلات) لتحديد المسلك الأمثل. البحث يعرض الخوارزمية المقترحة لإظهار المسار المثالية الأفضل من المصدر إلى الوجهة