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ANTNET:ACO based routing algorithm

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Abstract: AntNet is an ACO based routing algorithm for distributed and traffic adaptive multipath routing in wired best-effort IP networks. Forward ants in AntNet collect traffic behavior and backward ants are used to update probabilistic routing tables based on the collected information.
Keywords—*connectionless-network, mobile ants, traffic adaptive, multipath, network performance*

I. INTRODUCTION

Internet has changed the face of lives of people turning them completely into modern. Internet is becoming an important tool in density; everybody across the world wants to connect to this fast source of information communication and gathering for their business or daily works. The internet is vast infrastructure of networked computers that have ability to share data around the world. Routing is one of the major parts of internet, routing is the process of selecting paths in a network along which data to be sent. Routing is the main characteristic of any network control system which strongly affects the network performance. There are two important parts of routing problem, the first one is communication structure which defines constrains and the second one is the traffic pattern which is dependent on the communication structure. So an ideal routing algorithm is one which is able to obtain an optimal solution by considering the specific temporal and spatial distribution of the input traffic and to deliver the packet to its destination with minimum amount of delay. It must be truly adaptive and intelligent enough to make the decision according to changing traffic condition. There are mainly two approaches for routing algorithms, distance-vector algorithms and link-state algorithms. The Open Short Path First is a shortest path algorithm is a link-state algorithm based on topology broadcast and is able to be fully and effectively adaptive with respect to topological modification, such that a link cost are static and may change only when network components become unreachable or new one comes up. Distance vector algorithms use the Bellman algorithm they do not make explicit use of global network topology and only use the notion of distance that is when a link becomes suddenly unavailable, in the worst case it might take infinite time to adjust the routing tables accordingly. The present routing algorithms are not sufficient enough to provide true adaptivity according to changing traffic patterns and very few algorithms make use of multipath.

These are some basic reasons due to which Ant based routing is developed in recent years. The concept of software agent used for control in telecommunication was introduced by S.Applebly and S.Steward [1]. R.Schoonderwoerd modified the approach of software agents for routing problem [2]. This research continues and it was further applied to connection-oriented networks. The ACO based routing is then applied to connectionless networks [3]. Gianni Di Caro and Marco Dorigo proposed AntNet an Ant Colony Optimization (ACO) based data network routing algorithm. In this network routing algorithm, there are two types of mobile agents (or artificial ants) one is of forward ants which explores the network concurrently, examine the traffic pattern of following path and exchanges the obtained information with backward ants so that they can update the routing tables. This updated information is then used to direct the data packets towards their destination.

II. ANT COLONY OPTIMIZATION

Ant Colony Optimization is an optimization technique proposed by Marco Dorigo in early '90, is a family of optimization algorithms based on real ants behaviour [5]-[8]. ACO is a colony of autonomous and concurrent agents for designing metaheuristic algorithms for combinatorial optimization problems.

The ACO metaheuristic is based on a multiagent architecture. The agents of system which are ants have inspired by the foraging behaviour of ant colonies, have a double nature. On the one hand, they act similar to behaviour of real ants which find the shortest path to food source. On other hand they have the capabilities which do not find a natural counterpart, but which are in general necessary to obtain performance when system is applied to difficult optimization tasks. In ACO the set of mobile agents are allocated with computational resources, so that they can iteratively and concurrently construct multiple solutions in relatively computational and simple way.

ACO algorithm for routing provides traffic adaptive and multipath routing, rely on both passive and active information monitoring and gathering, making use of stochastic components, do not allow local estimates to have global impact, set up paths in a less selfish way than in pure shortest path schemes favouring load balancing, show limited sensitivity to parameter setting.

III. ANTNET ROUTING ALGORITHM

AntNet is an ACO algorithm for distributed and traffic adaptive multipath routing in wired best effort IP networks. AntNet's design is based on ACO's general ideas as well as on the work of Schoonderwoerd et al, which was a first application of algorithms inspired by the foraging behaviour of ant colonies to routing tasks. AntNet behaviour is based on the use of mobile agents, the ACO's ants that realize a pheromone-driven Monte Carlo sampling and updating of the paths connecting sources and destination nodes. The AntNet's general structure is quite simple and closely follows the ACO's guidelines. During the forward phase each mobile ant-like agent constructs a path by taking a sequence of decisions based on a stochastic policy parameterized by local pheromone and heuristic information (the length of the local link queues). Once arrived at destination, the backward phase starts. The ant retraces the path and at each node it evaluates the followed path with respect to the destination (and to all the intermediate nodes) and updates the local routing information.

*A. **Data structure maintained at each node***

1. Pheromone matrix T_K is organized similarly to the routing tables in distance-vector algorithms but its entries Tnd are not distances or generic costs-to-go. The entries, in agreement with the common meaning attributed to pheromone variables in ACO, are a measure, for each one of the physically connected neighbour nodes $n \in N_k$ of the goodness of forwarding to such a neighbour a packet travelling toward destination d

$$\sum_{n \in N_k} T_{nd} = 1,\ d \in [1, N]\ N_k = \{\text{Neighbours } (k)\}$$

2. Data-routing table R_K is the routing table used to forward data packets. R_K is a stochastic matrix and has the same structure as T_K .The entries of R_K are obtained by an exponential transformation and re-normalization to 1 of the corresponding entries of T_K.
3. Link queues L_K are data structures independent from AntNet, since they are always present in a node if the node has been designed with buffering capabilities. The AntNet routing component at the node passively observes the dynamics of data packets in addition to the active generation and observation of the simulated data packets, that is, the ants.
4. Statistical parametric model M_K is a vector of N − 1 data structures (μd, $\sigma^2 d$, W_d), where μd and $\sigma^2 d$ represent respectively the sample mean and the variance of the travelling time to reach destination d from the current node, while W_d is the best travelling time to d over the window of the last w observations concerning destination d.

*B. **The AntNet Algorithm***

1. At regular time intervals Δt from every node s, a forward ant $F_{s\to d}$ is proactively launched toward a destination node d to discover a feasible, low-cost path from $s\to d$ and at same time to investigate the load status of the network along followed path. Destination of forward ant is chosen as d with a probability p_d.

$$p_d = \frac{f_{sd}}{\sum_{i=1}^{N} f_{sd'}}$$

Where f_{sd} is the number of bits (or packets) bounded for d so far have passed by s.

2. While travelling toward their destination nodes, the forward ants keep memory of their paths and of the traffic conditions encountered. The identifier of every visited node k and the step-by-step time elapsed since the launching time is saved in appropriate list structures contained in the ant's private memory H. The role of ant private memory H is to avoid loops when possible.
3. At each intermediate node k, the forward ant $F_{s\to d}$ towards its destination d must select the neighbour node $n \in N_k$. If all the neighbours have already been visited by the forward ant, then the ant choose the next hop by picking up at random of one of neighbours, without any preference but excluding the node from which the ant arrived in k.
4. The next neighbour n as next hope with probability p_{nd} is chosen among the nodes that have not been visited as:

$$p_{nd} = \frac{T_{nd}+\alpha l_n}{1+\alpha(|N_k|-1)}$$

Here, N_K represents the set of neighbours of the current node k and $|N_K|$ the cardinality of that set, i.e., the number of neighbours. The values Tnd of pheromone's matrix T_K for choosing n as next hop for destination d. The value of $\alpha \in [0, 1]$. The values l_n based on the status of the local link queues.

$$l_n = 1 - \frac{q_n}{\sum_{l=1}^{|N_K|} q_{n'}}$$

l_n is a [0,1] normalized value proportional to the length qn, in terms of bits waiting to be sent, of the queue of the link connecting the node k to its neighbour n.

5. When the destination node d is reached, the forward ant Fs→d is transformed into backward ant Bd→s and it inherits its entire memory form forward ant and forward ant dies.

6. The backward ant follows the same path as that of its corresponding forward ant, but in the opposite direction. This means backward ant traces the path of forward ant. Backward ants don't share the same link queues as data packets or forward ants; they use higher priority queues, they assign a measure of goodness to the path followed by corresponding forwards ants, because their task is to quickly propagate to the routing tables the information accumulated by the forward ants.

7. Arriving at a node k coming from a neighbour node f, the backward ant mainly updates two data structures of the node, the local model of the traffic M_K and the routing table R_K, for all the entries corresponding to the (forward ant) destination node d.

C. Update Traffic model M_K

M_K is updated consulting the list $T'_{k\rightarrow d}$ and considering the value $T_{k\rightarrow d}$ of travelling time experienced by forward ant while travelling from k to d where k is the current node. M_K is vector of N-1 data structures which is updated corresponding to the values of μ_d, σ^2_d, W_d.

$$\mu_d \leftarrow \mu_d + \eta\,(o_{k\rightarrow d} - \mu_d)$$

$$\sigma^2_d \leftarrow \sigma^2_d + \eta\,((o_{k\rightarrow d} - \mu_d)^2 - \sigma^2_d)$$

Where $O_{k\rightarrow d}$, represents minimum time for destination d from current node k. μ_d is mean of travelling time to reach destination d from current node, σ^2_d variance of travelling time to reach destination d from current node, W_d is best travelling time to d over the window of last W observation.

$$W = \frac{5c}{\eta} \quad \text{where } c \in (0, 1],\ \eta = 7.2$$

If the newly observed forward ant's trip time $O_{k\rightarrow d}$ from the node k to the destination d is less then tbestd then *tbestd* is replaced by $O_{k\rightarrow d}$.

D. Update Pheromone matrix T_K

The pheromone table T_K is updated by incrementing the probability of T_{fd} (the probability of choosing f when destination is d for current node k) and decrementing the probabilities T_{nd}, where $n \in N_K$, all other neighbour nodes of k.

$$T_{fd} \leftarrow T_{fd} + r\,(1 - T_{fd})$$

$$T_{nd} \leftarrow T_{nd} - r\,(T_{nd})$$

r is a dimensionless value which is used by the current node k as a positive reinforcement for the node f the backward ant $B_{d \rightarrow s}$ comes from. r is assigned taking into account the so far observed travelling times such that the smaller $T_{k \rightarrow d}$ is, the higher r is. $r \in (0, 1]$.

E. Update Data routing table R_K

The data routing table is used to forward data packet is updated after every update in pheromone table. The entries of data routing table are obtained by an exponential transformation and renormalization to 1 of corresponding pheromone table values.

$$R^{k}_{nd} = (T_{nd})^{E}, \quad E = 1.4$$

F. Limitation of Antnet Algorithm

AntNet is much better algorithm then present non- ACO based algorithms as it is highly adaptive, uses multipath and stochastic policy for routing data packets but still there is a problem with this ACO based algorithm. One of the major problem is when a path is followed from source node to destination node it is followed with higher probability to a destination .If a path is having good condition for certain period of time, its probability to a destination increases, which in return encourage all data packet to follow the same path which will increase congestion after certain duration of time. It also reduces probability of selecting other paths. Hence the node will stuck to that outgoing link of particular node and does not retains its adaptive ability. This is called the problem of "stagnation". Stagnation is reached when a node reaches its convergence.

Let this should be explained through an example

Referring to Figure 1, let us consider a forward ant originating in A with destination B. Let us assume that nodes 1, 2, 3, 4 are experiencing a sudden increase of the traffic directed toward node B.

Being these nodes directly connected to B, most of this traffic is forwarded on the link directly connected to B. Due to the fact that the increase of traffic from 1, 2, 3, 4 to B happened suddenly, node A is not yet completely aware of the new traffic situation. The forward ant is therefore routed to node 1, considered that the quickest known path from A to B was the two-hop path passing through 1. Unfortunately, once in 1, the length of the link queue L_1B forces the ant to move to 2, also considered that the path through 2 should have a travelling time comparable to that through 1. Again, the congestion on the link directly connected to B moves the ant to node 3, and then further to node 4. Here, the two possible alternatives are: the three hops, congested path <10, 11, B>, and the path through C. The ant moves to C, which had a competitive travelling time to B, before the congestion at 1, 2, 3, 4 due to the direct connection of C with 1 and 2. Once in C the ant, to avoid the cycles, must move to 5. At this point the path of the ant is constrained along the very long path <5, 6, 7, 8, 9, B>. Therefore, in the end, the ant's list $V_{A \rightarrow B}$ will contain [A, 1, 2, 3, 4, C, 5, 6, 7, 8, 9, B]. The considered situation is expected to happen quite often undernon-stationarity in the input traffic processes.

Let us consider the possible update actions of the backward ant in A. In principle, the backward ant can update the estimates concerning all the sub-paths from A to any of the nodes in $V_{A \rightarrow B} \setminus \{A\}$. For instance, using the experienced value of $T_{A \rightarrow C}$, the backward ant could update in A the estimates M_{AC} for the travelling times to C, and, accordingly, the value T1C of the goodness of choosing 1 as next hop for C as destination. The value $T_{A \rightarrow C}$ corresponds to the long, jammed path <A, 1, 2, 3, 4, C>. But this path is "wrong", in the sense that if the destination was C, the next hop decision in A, or either in 1 or2, would have been different. Likely, the path followed would have been either <A, C>, or <A, 1, C>, or<A, 1, 2, C>. In this sense, the use of the experienced value $T_{A \rightarrow C}$ to update in A the estimates concerning C are substantially incorrect.

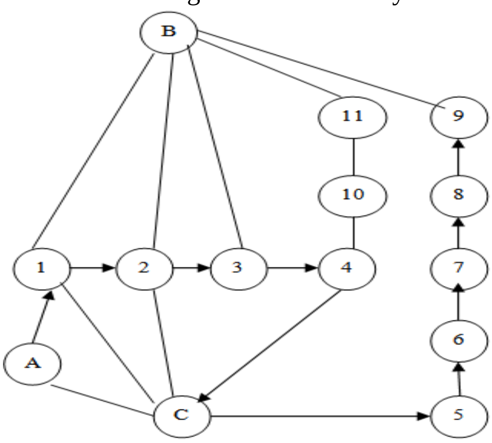

Fig1. Limitation of AntNet Algorithm

IV. Conclusion

AntNet is multipath, adaptive ACO based routing algorithm. In AntNet there are two types of mobile agent one is forward ant and the other is backward ant. Forward ant retraces the traffic condition of the path and backward ant update the data structures present at each node. One of the major problems is that the network gets trapped because a node prefers a link with higher probability to a destination when choosing an outgoing link. This problem can be solved by modifying this optimization technique and applying optimization techniques to the present algorithm so that solution to the stagnation problem is discovered.

References

[1] S. Appleby and S. Steward, "Mobile software agents for control intelecommunication networks," *BT echnol.* vol. 12, no. 2, 1994.

[2] R. Schoonderwoerd, O. Holland, J. Bruten, and L.Rothkrantz,"Ants for Load Balancing in Telecommunication Networks," *Hewlett Packard Lab., Bristol, U.K.*, Tech. Rep. HPL-96-35, 1996.

[3] D.Subbramanian, P.Druschel,and J.Chen,'Ants and reinforcement learning: A case study in routing in dynamic networks",*Proce of IJCAI-97,Palo Alto,Morgan Kauffman*,1997,pp 832-838

[4] E. Bonabeau,D.Suyers,"Routing in telecommunication networks with smart like agents ",*Proceedings of LATA,1998*

[5] M. Dorigo and G.D.Caro,"Antnet: A mobile agents approach to adaptive routing ",Tech Report, *University Libre de Bruxelles,IRIDIA,1997*.

[6] G. D. Caro and M. Dorigo, "AntNet: Distributed stigmergetic control for communications networks," *Journal of Artificial Intelligence Research*, 9,1998 vol. 9, pp. 317–365,1998.

[7] G. D. Caro and M. Dorigo, "Ant colonies for adaptive routing in packets witched communications networks," in Proc. *5th Int. Conf. Parallel Problem Solving from Nature, Amsterdam,* The Netherlands, Sept. 27–30, 1998.

[8] G. D. Caro and M. Dorigo, "Two ant colony algorithms for best-effort routing in datagram networks," in Proc. 10th IASTED *Int. Conf. Parallel Distributed Computing Systems,* 1998, pp. 541–546.

[9] Kwang Mong Sim and Weng Hong Sun, "Ant Colony Optimization for Routing and Load-Balancing: Survey and New Directions ",*IEEE transactions on systems and humans*,Vol.33,No.5 Sept 2003.

[10] Marco Dorigo and Krzysztof Socha," An Introduction to Ant Colony Optimization "IRIDIA- *Technical Report Series Technical Report No.TR/IRIDIA/2006-010* April 2006, Last revision: April 2007.

[11] M. Dorigo, G. D. Caro, and L. M. Gambardella, "Ant algorithms for discrete optimization," *Artif. Life*, vol. 5, no. 2, pp. 137–172, 1999.

[12] B. Baran and R. Sosa, "A new approach for AntNet routing," presented at the *Proc. 9th Int. Conf. Computer Communications Networks, Las Vegas, NV,2000*.

[13] T. Stuzle and H. H. Hoos, "MAX-MIN ant system," *Future Gener. Comput.Syst. J.*, vol. 16, no. 8, pp. 889–914, 2000.

[14] M. Dorigo and G. Di Caro. The ant colony optimization meta-heuristic. In D. Corne, M. Dorigo, and F. Glover, editors, *New Ideas in Optimization*, pages 11–32. McGraw-Hill, 1999.