
Source routing: Best rout using genetic algorithm

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Abstract

The success of distributed multimedia traffic presents many challenges to the network designer, certain bandwidth as well as bounds on delay, loss probability and jitter in order to maintain reception quality are issues of Constraint Base Routing (CBR). Flow routing requires deterministic path coordination in comparison with data routing. This paper presents a new technique for best CBR-rout path computation using genetic algorithm. Available bandwidth, delay jitter, and path availability are the fitness function, the genetic algorithm try to optimize. Source routed packets were established to hold the complete elected path in packet header. All studies made on NS2 simulator, where SARBE approach for rapid on-line estimation of available bandwidth shows performance optimization on OSPF algorithm for multimedia streaming applications.

1 Introduction

Today Internet packet forwarding is based on the destination address. Simple routing algorithms that determine forwarding paths based on the minimum number of hops or delay to a specified destination are no longer sufficient. This show the need for dynamic traffic routing, that aim at improving the utilization of a transportation network capacity which is a challenging task that involves solving a complex optimization problem.

Routing in general involves two entities, namely the *routing protocol* and the *routing algorithm*. The routing protocol manages the dynamics of the routing process: capturing the state of the network and its available network resources and distributing this information throughout the network. The routing algorithm uses this information to compute paths that optimize a criterion and/or obey constraints.

routing strategies can be classified according to Mechanisms for triggering search for feasible paths into [1]:

-Pro-active routing: In this approach, routes to various destinations are maintained at all times (pre-computed), whether they are required or not.

-Reactive routing: In this approach, routes to destinations are computed when they are needed (on-demand). This approach reduces overhead, at the expense of slower response times.

A routing and forwarding technique sometimes applied in the Internet in source routing. *Source* routing is a technique in which the source specifies the whole path to the destination in the packet header, whereas. Typically, any routing strategy is employed within a domain, but across domain boundaries, only aggregate information is advertised.

Constraint base routing is an important field in QoS routing section two will explain constraints and its types, whereas available bandwidth and delay metric will explained in section tree and four respectively.

genetic based routing algorithm and its implementation are explained in . Section five and the follow.

2 Constraint Base Routing

Traffic Engineering is of increasing interest in today's networks. One of the objectives of Traffic Engineering is to obtain more control over the path packets take: to be able to specify explicitly the path that a certain class of packets takes.

Constrained-Based Routing CBR takes this one step further. Instead of specifying the path explicitly, link by link, one specifies a route in terms of the constraints that it should satisfy. The route specification is then automatically converted into an explicit path [2],[3], and [4].

CBR requires mechanisms for:

- (1) exchanging state information among CBR processes.
- (2) maintaining this state information.
- (3) interacting with the current intra-domain routing protocols.
- (4) accommodating traffic requirements.

Constraint-base path computation can be performed off-line depending on traffic demand matrix and network topology for optimizing resource planning, otherwise, path computation may performed without prior knowledge of traffic request for the purpose of rout state update.

Constraints can be classified into :

1. Boolean Constraints and their Resources
 Boolean constraints include: administrative group constraints, bandwidth availability, delay bounds, and hop count bounds. The resources corresponding to the Boolean constraints are: administrative groups configured on links, available bandwidth on links, configured delay on links and nodes, and path length.

2. Quantitative Constraints and their Resources

Quantitative constraints include residual bandwidth ratio, path metric, and hop count. The resources corresponding to quantitative constraints are: residual bandwidth, metric, penalty and path length. Each route specifies the list of qualitative constraints that should be enforced, and in what order.

3 Available bandwidth

Inferring the unused capacity or *available bandwidth* on an end-to-end path is of great importance for various network applications, it can improve rate-based streaming applications [5], end-to-end admission control [6], etc.

A route can specify a required bandwidth RB and a priority p . A link has three types of bandwidth information: available bandwidth, AB ; maximum bandwidth for a route, MB ; and total reservable bandwidth, TB . A link satisfies the bandwidth constraint iff both its available bandwidth AB and the maximum bandwidth are at least as much as the specified bandwidth. If the final computed path includes this link, preemption will be required if $RB > LB$.

AB is initially the reservable bandwidth of link L ; this value changes as reservations are made and withdrawn.

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if  $RB \leq AB \ \&\& \ RB \leq MB$  then
    Accept reservation
else
    Reject reservation
    
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Many tools had been adopted to infer AB, such as train of packet pair [7], packet pair [8], and PathChirp [8]. All of these approaches comprise receiver base analysis, source routing must implement sender base analysis.

In this paper we take the advantage of using ACKs sending time interval to achieve a more accurate available bandwidth estimate. stable accurate rapid bandwidth estimate SARBE approach employs the ACKs sending time intervals to compute the available bandwidth of the forward path via the timestamp in ACK.

$$Bw_k = \frac{L_k}{ts_k - ts_{k-1}} \quad (1)$$

where L_k is the amount of data acknowledged by the k th ACK, ts_k is timestamp of the k th ACK; ts_{k-1} is the timestamp of the previous ACK arrived at the sender. It can be seen obviously, sample Bw_k represents the current network condition, which faces noises. So the bandwidth estimator has to eliminate transient noise but responds rapidly to persistent changes.

$$U[k] = \beta * U[k-1] + (1 - \beta) * |Bw[k] - Bw[k-1]| \quad (2)$$

$$U_{max} = \max(U[k-N], \dots, U[k-1], U[k]) \quad (3)$$

$$eBw[k] = \alpha eBw[k-1] + (1 - \alpha) * Bw[k] \quad (4)$$

where $U[k]$ is the network instability ($\beta = 0.8$); U_{max} is the largest network instability observed in the last N instabilities ($N=8$);

This approach were first used to estimate available bandwidth automatically to improve TCP congestion avoidance behavior. In SARBE approach, the estimate of the forward path is not be affected by ACK compression that results in overestimate.

When the k th ACK arrives, the sender simply uses information of the k th ACK to compute an available bandwidth sample, which can be written as

We used the stability-based filter [7]. After computing the bandwidth sample Bw_k from (1), the stability-based filter can be expressed in the recursive form

and eBw_k is the estimated smoothed bandwidth, eBw_{k-1} is the previous estimate and the gain α is computed dynamically as (3) when the bandwidth samples vary largely.

4 Resource availability and delay jitter

Rout table associate delay metric with each link. Network resources always varied because of dynamic nature and fault occurrence within networks, thus rout table must keep track with such updates.

5 Genetic-base routing

genetic algorithm is a powerful searching algorithm, it depend on evolution bases to elect the optimal solution from the problem space. It comprise three basic steps:

- 1- selection : selecting individuals from the problem space (population).
- 2- Crossover: process of mating two solutions (parents) and exchanging data between them for finding new solutions (children)
- 3- Mutation : process of exchanging piece of information within the hole solution to prevent sticking in local sub-optimal solution.

the very important issues that must be taken into account in routing problems are :

- 1- Solving crossover operation with variable length chromosomes.
- 2- Regarding node connectivity in new chromosomes.
- 3- Solving multi constraint fitness function.

Subsequent sections describe these issues in detailed.

5.1 Crossover for variable length chromosome : The crossover operation of conventional genetic algorithm is based on an exchange between two chromosomes of fixed length when a bit string representation is used. In the proposed crossover scheme,

the two chromosomes chosen for crossover can have different lengths. However, they must have at least one gene (cell) in common except for the origin and destination cells. When two chromosomes have more than two common genes, the proposed GA will randomly choose one of them as the crossover point. For example:

Parent chromosome 1:

0 – 1 – 2 – 7 – **12** – 17 – 22 – 23 – 24

Parent chromosome 2:

0 – 5 – 10 – 11 – **12** – 13 – 19 – 24

A valid crossover point D5 exists. The result after crossover will be:

Child chromosome 1:

0 – 1 – 2 – 7 – **12** – 13 – 19 – 24

Child chromosome 2:

0 – 5 – 10 – 11 – **12** – 17 – 22 – 23 – 24

This crossover pre-condition of commonly-shared genes between two chromosomes might be so strict that the performance of resultant GA suffers great degradation. If that is the case, the pre-condition can be loosened to allow crossover operation when two parent chromosomes have a pair of genes within the same neighborhood (neighboring cells). The pair of genes is included in both child chromosomes after crossover.

For example,

Parent chromosome 1:

0 – 1 – 2 – 8 – 14 – 19 – 24

Parent chromosome 2:

0 – 5 – 10 – 11 – 12 – 17 – 22 – 23 – 24

Node 12 and node 8 are in the same neighbor. The result after crossover will be:

Child chromosome 1:

0 – 1 – 2 – **8** – **12** – 17 – 22 – 23 – 24

Child chromosome 2:

0 – 5 – 10 – 11 – **12** – **8** – 14 – 19 – 24

It is possible that loops are formed in resultant routes after crossover. The crossover may generate infeasible chromosome that includes the same nodes twice.

Child chromosome 1: 0-1-2-**8-12-8**-14-19-24
 Child chromosome2:0-5-10-11-**12**-17-22-23-24

Hence, a repair function is needed to eliminate any loop in a possible route. The simplest way to deal with loops in the route by searching duplicated nodes and eliminating the loop by exchanging the first duplicated nodes with its neighbors suppose node_i is the first occurrence of duplicate node then the new node should be taken from the intersection set of previous-next node neighbor to assure path connectivity equation (5).

$$\{\text{New node}_i\} = \{\text{neighbor}(\text{node}_{i-1})\} \cap \{\text{neighbor}(\text{node}_{i+1})\} \quad (5)$$

Then we choose one of the new node set to exchange duplicate node, new child chromosome2 after preparing will be :

Child chromosome 1: 0-1-2-**7-12-8**-14-19-24

This process will repeated until free-loop chromosome obtained.

5.2 Connectivity processing

Crossover process may result in new child with unconnected nodes such chromosome can be discarded with low fitness by using the delay metric .

$$d = \begin{cases} d \approx \infty & \text{if there is noconnectivity} \\ d = \text{link_delay} & \text{otherwise} \end{cases} \quad (6)$$

5.3 Multi-constraint fitness

In this research the genetic algorithm try to solve multi constraint fitness function, delay and available bandwidth metrics.

$$\text{fitness} = \frac{1}{\min ebw_i + \sum d_i} \quad (7)$$

Where

eBw_i is link i estimated bandwidth

d_i is link i delay

6 Source Routing

The Internet Protocol is designed [8] for use in interconnected systems of packet-switched computer communication networks.

The internet protocol uses four key mechanisms in providing its service:

Type of Service, The Type of Service is used to indicate the quality of the service desired.

Time to Live, The Options provide for control functions needed or useful in some situations but unnecessary for the most common communications.

Options, The options include provisions for timestamps, security, and special routing.

and Header Checksum.

Strict Source and Record Route SSRR. (Option 137), provides a means for the source of an internet datagram to supply routing information to be used by the gateways in forwarding the datagram to the destination, and to record the route information. Figure(1) depict this option fields.

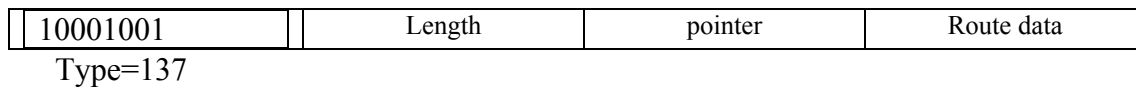


Figure (1) SSRR fields

The option begins with the option type code. The second octet is the option length which includes the option type code and the length octet, the pointer octet, and length-3 octets of route data. The third octet is the pointer into the route data indicating the octet which begins the next source address to be processed. The pointer is relative to this option, and the smallest legal value for the pointer is 4.

A route data is composed of a series of internet addresses. Each internet address is 32 bits or 4 octets. If the pointer is greater than the length, the source route is empty (and the recorded route full) and the routing is to be based on the destination address field.

If the address in destination address field has been reached and the pointer is not greater than the length, the next address in the source route replaces the address in the destination address field, and the recorded route address replaces the source address just used, and pointer is increased by four.

The recorded route address is the internet module's own internet address as known in the environment into which this datagram is being forwarded.

This procedure of replacing the source route with the recorded route (though it is in the reverse of the order it must be in to be used as a source route) means the option (and the IP header as a whole) remains a constant length as the datagram progresses through the internet.

This option is a strict source route because the gateway or host IP must send the datagram directly to the next address in the source route through only the directly connected network indicated in the next address to reach the next gateway or host specified in the route.

Must be copied on fragmentation. Appears at most once in a datagram.

Simulation and results

Network with 25 node were selected for simulation connection were designed to allow multi path alternate from source to destination. Figure (2) depict the network.

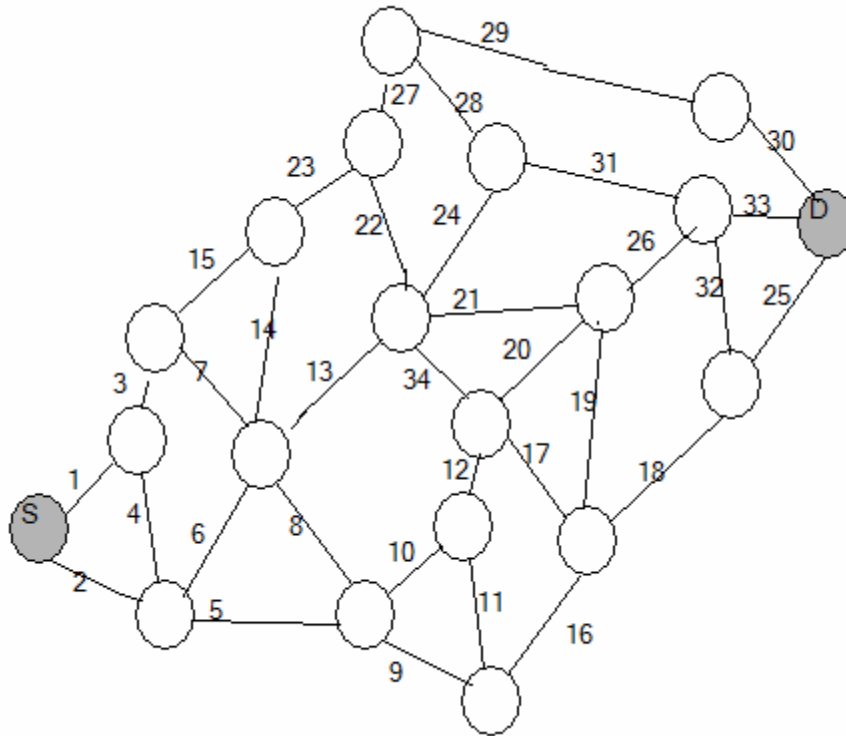


Figure (2) network topology

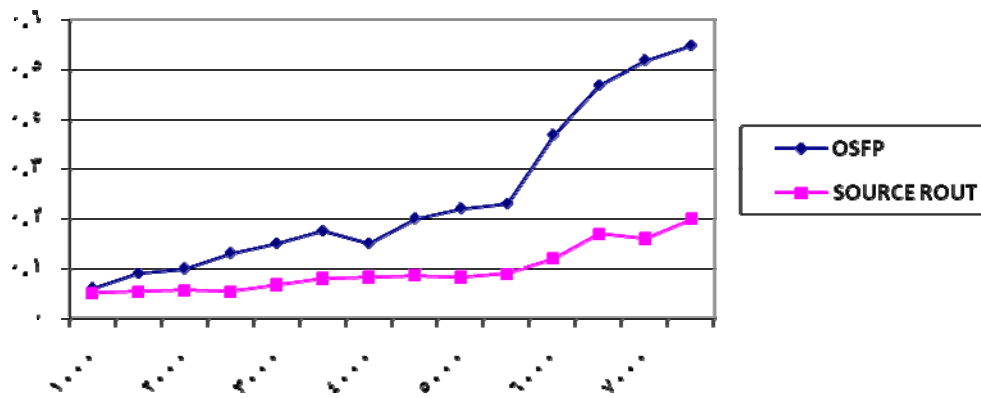
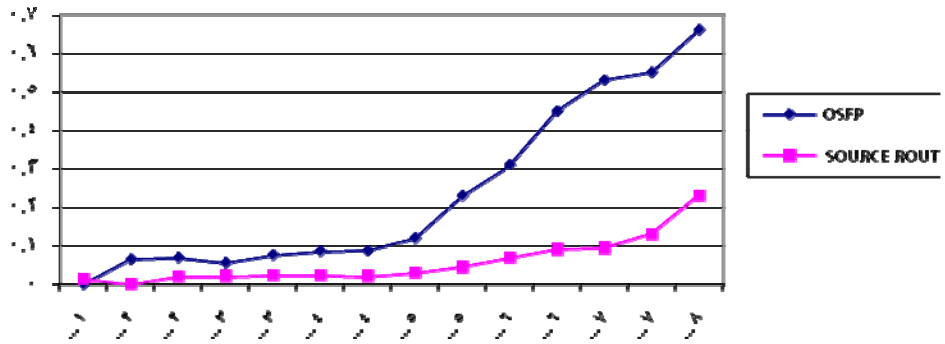
Each link associated with delay metric, and an inferred available bandwidth. Using Simulation environment configuration shown in table (1) bellow.

parameter	Value
Network node	25 node
Bandwidth estimation parameter	
P (packet size)	1000 byte
α (smoothing factor)	0,75
γ (spread factor)	1.2
L (busy period threshold)	5
Genetic algorithm parameters	
Cross over probability	80%
mutation probability	3%
Initializing population	30

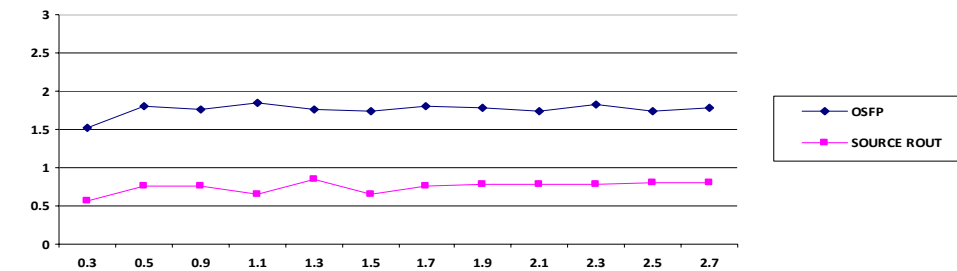
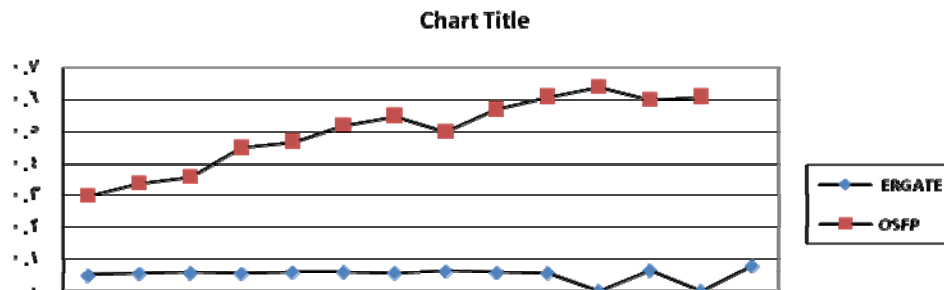
Senario1:

Network simulator NS2 [13] was used to simulate the proposed network with 25 node as depicted in figure(2). S refer to the source and D the destination. A constant bit rate CBR traffic was generated in node 4 to mimic real network environment. S generate TCP traffic and calculate eBw_k as mentioned in equation (4), then an optimized source routing applied.

Delay =
 $\text{packetsize}/\text{bandwidth} + \text{Transmission Delay}(7)$
 comparison had been made using OSPF protocol, figure () depict the performance evaluation.



Havey train



Conclusion

Simple OSPF algorithm become insufficient for streaming multimedia application. Using source routing is a powerful tool for controlling flow routing flexibly.

Our algorithm take benefit from using SARBE approach for rapid on-line estimation of available bandwidth, the results show performance optimization in:

- 1- Congestion avoidance
- 2- Accurate load distribution
- 3- Dynamic routing.

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الخلاصة :

يعد النجاح في الانظمة المتعددة الوسائط تحديا كبيرا لمصممي الشبكات، حيث يعتبر الحصول على عرض رزمة bandwidth مع حدود معينة للتأخير، احتمالية خطأ قليلة من اهم العوامل التي يحاول ان يطورها الباحثون في حقل التوجيه المعتمد على الضوابط (constrained base routing CBR) من اجل الوصول الى افضل نتيجة لنقل البيانات. يقترح هذا البحث تقنية جديدة في (CBR) باستخدام الخوارزميات الجينية . حيث تم استخدام معاملات الحزمة المتبقية available bandwidth ، عامل التأخير و توفر المسار المطلوب كمعاملات لحساب دالة الكفاءة fitness function ثم يتم خزن المسار باكماله في الرزم المرسله. تم اعتماد جميع النتائج في هذا البحث باستخدام نظام المحاكاة NS2 . وظهرت النتائج تقديما في استخدام خوارزمية SARBE على خوارزمية OSPF والتي لم تعدم كفاءة في نقل البيانات المتعددة الوسائط