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Research Article

Optimization of IPv6 Protocol Independent Multicast-Sparse Mode Multicast Routing Protocol based on Greedy Rendezvous Point Selection Algorithm

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Abstract: Forming of the Multicast tree with the best root considered as center selection problem (typically classified as NP-complete type). Alternatively called center Rendezvous Point (RP) due to the direct impact on the multicast routing protocol in terms of the performance. This research article introduces a new compound solution for multicast RP selection called Greedy based RP Selection Algorithm (GRPSA) to select the best RP for PIM-SM multicast routing protocol in IPv6 multicast domain based on Fitness or cost criteria supported by Dijkstra algorithm. The paperwork passes through two phases. First, MATLAB phase used for GRPSA implementation assisted by Fitness calculation to select the best RP called Native-RP. The second phase investigates the performance of GRPSA using QoS metrics compared to another candidate RPs. Validated using the GNS3 emulator for the core IPv6 multicast network and realized using UDP streaming data sourced from Jperf traffic generator via virtual machines at the network edges. The multicast technology implements a very high-efficiency point-to-multipoint data transmission over IP networks (IPv4 and IPv6). The results show GRPSA-RP performs better than other possible RPs by 25.2%, 25.3%, 46.2% and 62.9%, in terms of data received, bandwidth, jitter and loss respectively on average.

Keywords: IPv6, multicast, PIM-SM routing protocol, Rendezvous Point (RP)

INTRODUCTION

The Rapid growth of Internet communications continues to create new services and network applications. Meanwhile, the massive growth in the number of concurrent users who want simultaneously access shared data in corporate intranets with competitive cost drives the global Internet to provide more shared services. In addition, many real-time applications appeared, such as video conferencing, audio, collaborative environments, IPTV (Lloret *et al*., 2011). Most multicast applications include a source send messages to a selected group of receptors, but the broadcast and unicast network communication are not optimal for this application kind. So appeared technology called IP multicast (Bartczak and Zwierzykowski, 2012; Joseph and Mulugu, 2011). Multicast utilizes network infrastructure efficiently by requiring the server or source to send out a stream of packets only once to the multicast group's address, the nodes in the network take care of replicating the packet to reach multiple receivers only where necessary (Taqiyuddi *et al*., 2008). Moreover, the multicast can scales to a larger receiver population by not requiring prior knowledge of who the receivers are or how many there are. In addition, multicasting preserves bandwidth on the network and eliminates traffic redundancy. IP multicast available for both versions of Internet Protocols, IPv4 multicast and IPv6 multicast, but due to the low address space of IPv4 cannot provide the necessary support for multicast communication multicast (Bartczak and Zwierzykowski, 2012; Joseph and Mulugu, 2011). It may happen that multicast will be the main driving force behind the widespread use of the IPv6 protocol (Bilicki, 2006). Multicasting also provides enhanced efficiency by controlling the traffic on your network and reducing the load on network devices. The clients on your network are able to decide whether to listen to a multicast address, so packets only sent to where they are required. In addition, multicasting is scalable across different sized networks but is particularly suited to WAN environments. It enables people at different locations access to streaming data files, like a video, film or lives presentation without taking up excessive bandwidth or broadcasting the data to all users on the network. Multicast communication uses multicast distribution tree for data routing. Typically, defined as either source or share based tree. Source-based tree creates separate multicast routing tree for each source, while shared multicast tree creates one tree for the whole group and shared among all sources. In addition, shared tree has an advantage

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over source tree because only one routing table needed for the group. Shared multicast trees require the selection of a central router called "Core Point" in the case of CBT multicast protocol (Ballardie, 1997) and "Rendezvous point or RP" in the case of PIM-SM (Fenner *et al*., 2006).

The current paper focuses on shared tree type using PIM-SM in which the right selection of RP router is very important and considered as an NP-complete problem (Wang *et al*., 2010; Zappala *et al*., 2002), which advised to be resolved with a heuristic algorithm. Also, an optimized Greedy-based RP Selection Algorithm (GRPSA) is proposed and implemented to achieve the research contribution. It presents an adaptive approach to evaluating the Defects and Features of the multicast tree through considering both cost and QoS factors, by realizing RP selection with the local search algorithm.

Bartczak and Zwierzykowsk (2009) described the comparison between different multicast routing protocols for different approaches. It focuses on similarities and differences between PIM-SM protocol that uses source tree and PIM-DM protocol that practice shared tree. The research covered IPv4 multicast only.

Wang *et al*. (2010) suggested tabu search algorithm in PIM-SM multicast routing to select multicast RP because PIM-SM uses shared tree and the main problem is how to determine the position of the RP. The algorithm selects multicast RP by considering both cost and delay. The outcome of Wang's proposed algorithm indicates good performance in multicast cost, ETE delay and having good expansion and practical feasibility. However the paper doesn't consider RP reselection after the dynamic join and leave of group members (Wang *et al*., 2010).

Youssef Baddi, Mohamed Dafer, introduces D2V-VNS-RPS (Delay and delay variation constrained algorithm based on Variable Neighborhood Search algorithm for RP Selection problem in PIM-SM protocol). This algorithm selects the RP router by considering tree cost, delay and delay variation. The main motivation behind the use of VNS search algorithm was to solve core selection problem using several neighborhoods to explore different neighborhood structures systematically. Simulation results show that D2VVNS-RPS got better average delay compared to other tested algorithms such as TRPS, DDVCA and Random. The algorithm shows the less cost compared with the tested algorithms (Baddi and El Kettani, 2012) but still, the experiments require further validation using emulators behind simulators for further QoS investigation such as throughput and available bandwidth.

Youssef Baddi, Mohamed Dafer, presented 2DV GRASP-RP (Delay and Delay Variation) algorithm based on Parallel GRASP Procedure (Greedy Randomized Adaptive Search Procedure) using PIM-SM multicast routing protocol to select the right RP by considering cost, delay and delay variation functions. As a result, the algorithm shows good performance in terms of multicast cost, end-to-end delay and other aspects compared to other three algorithms; AKC, DDVCA and Tabu RP Selection algorithm (or TRPS) (Baddi and El Kettani, 2013). It focused on IPv4 multicast only.

Compared to the related works, the current paper introduces further investigation to the effect of the right RP selection on the performance of IPv6 multicast domain using QoS metrics such as throughput, available bandwidth, jitter and loss. Besides, a new algorithm tested and a real traffic generator is deployed for validation.

MATERIALS AND METHODS

Construction of IP Multicast tree and identifying the right RP selection criteria could considered as two most significant traffic-engineering factors in PIM-SMmulticast performance. To achieve our optimization target, the following steps discuss the proposed method:

Multicast PIM-SM problem and motivation: The essential problem in building multicast routing tree is how to find a low-cost tree covering all group members plus the path from source. This problem was attributing to a Steiner tree problem (Mehlhorn, 1988) in mathematics and considered as an NP-complete problem (Wang *et al*., 2010; Zappala *et al*., 2002). PIM-SM divides the multicast tree into two sub-problems: an RP selection problem and a routing selection problem. RP selection using PIM-SM protocol classified into two types: static and dynamic. When static selection is active, the IP address of RP must define on all routers. Unlike static, the dynamic depends on several ways, but the most important is abootstrap router (BSR) (Bhaskar *et al*., 2008). It works by sending the relevant information comprising priority and IP address of candidate-RP to all routers of the network. This information obtained from candidate-RP that willingness to be an RP. All routers use a hash function to select one RP address based on IP address, priority and hash-mask-length prepared by BSR. However, these steps do not guarantee the selection of the best RP position. In addition, the static and dynamic mechanisms for RP selection designed without care of cost (or distance of multicast group members). These limitations motivate us for further research contribution.

Basic greedy local search algorithm: A Local Search (LS) algorithm is an iterative search procedure begins from an initially suitable solution and this solution

```
BEGIN // basic greedy local search algorithm
  /* given a starting solution i and a neighborhood function n */
  set best = i;
  set iterations = 0;
  REPEAT UNTIL ( depth condition is satisfied) DO
  set count = 0;
  REPEAT UNTIL ( pivot rule is satisfied) DO
  generate the next neighbor j ∈ n(i);
  set count = count + 1;
  IF (f(j) is better than f(best)) THEN
  set best = j;
  end if
  End Do
  set i = best;
  set iterations = iterations + 1;
  End Do
END
```

Fig. 1: Pseudo code for basic greedy local search

improves progressively through execution a series of local modifications (or moves). The search then transitions to a "neighbor" that is "best" than the current candidate solution according to an objective function. The search halts when it faces a local optimum solution in relation to the transformations that it considers. The significant restriction of the method: unless one is quite lucky, this local optimum is often a mediocre solution. In LS, The quality of the solution obtained in addition to the computing times is commonly highly dependent upon the "richness" of the set of transformations (moves) considered at each iteration of the heuristic (Gendreau and Potvin, 2010). The basic LS (Eiben and Smith, 2015) algorithm is described in Fig. 1.

The proposed algorithm GRPSA for RP selection: The main goal of the proposed algorithm GRPSA is to solve/optimize the RP selection problem in IP multicast domain. The design, implementation and evaluation of GRPSA are achieved by dividing the research work into two phases; *MATLAB phase* for RP selection with the best tree rout computationally. The last is performance evaluation phase using GNS3-Jperf for testing and validation in terms of QoS metrics such as, jitter, loss and data received (Total throughput)with consideration of available bandwidth.

The rest of this section discusses the MATLAB implementation phase of GRPSA. Many transitions followed to get the best RP selection guided by a greedy approach based on the Fitness function. The formulation of the fitness function depends on assigning two weights; one weight signifies the impact of the distance from the source node to the selected RP, while the second weight determines the importance of the distance between RP and the destination nodes. The designed fitness function combines these two weights together to find the fitness values Eq. (1). If the calculated fitness for child-RP is smaller than the corresponding value of the parent-RP, it will select the child-RP as the new parent-RP, else parent-RP is selected (no change in parent RP):

$$Fitness = w_1 * dist(Scr, RP) + w_2 * \frac{\sum_{i=1}^{n} dis(Rp, Dest_i)}{n} \quad (1)$$

where,

- w_1 : The weight associated to the impact of distance between source node and RP
- w_2 : The weight associated to the impact of distance between RP and a destination node
- dist $(n1, n2)$: Shortest path distance between node n1 and n2.
- $Dest_i$: List of n destination nodes Dest = $\{Dest_1, Dest_2, \ldots\ldots Dest_n\}$.

The following outline activities of GRPSA algorithm, which are detailed next:

1. Set multicast topology (including source, receiver and links)
2. Find adjacency matrix of the network.
3. Compute shortest path (using Dijkstra algorithm) between every pair of nodes in the network
4. Randomly select an initial RP node (Parent-Rp) from all network nodes for the 1st round of the algorithm. The selected RP node should not belong to the source or destination nodes.
5. Then calculates the fitness value for the selected RP using Eq. (1).
6. RP mutation: It generates (Child-RP) from Parent-RP. The mutation operator depends on the proposed fitness function.
7. Calculate fitness of Child-RP.
8. Compare Parent-RP with Child-RP and select the best one according to the fitness values.
9. Iteration = iteration + 1.
10. If (iteration<max iteration) go to step 6 else end.

In summary of MATLAB phase, GRPSA produces the best-shared tree root (Native-RP) that optimizes the routes along the paths from source to destinations via the selected native-RP. The following pseudo-code structure outlines GRPSA algorithm.

GRPSA algorithm (pseudo code)

```
Input:
AdjNet // Adjacency network represents adjacency nods
Src //Source node
Dest //Set of destination nodes
MaxRun //Maximum number of iterations
Output:
Native RP
//It is Rendezvous point identified based on fitness values//represents the best shared tree root that optimizes the routes//along the paths from source to destination via this native-RP
Begin //main Func
//Apply Dijkstra Alg. Func to find the shortest distance (cost)
Set Distance ← DijkstraShortestPath (AdjNet)
```

```
//Find best RP called Native-RP node that gives the smallest fitness
    For all Run Number Do (where  1≤RunNumber ≤MaxRun)
//Select initial RP node randomly
Set RP ← InitialRP (AdjNet, Distance, Src, Dest)
// find a 2nd candidate RP node and compute fitness value for it
 Set RP ←Greedy (AdjNet, Distance, Src, Dest, RP)
//Save RP node number and fitness values per each RunNumber
Set BestRP (RunNumber) ← RP.Node;
Set BestFitness (RunNumber) ← RP.Fitness;
End For all RunNumber
// Sort the resulted candidate RP nodes in ascending order //according to //their best fitness values and then select the /node //(native RP) that gives minimum fitness(i.e. the first minimum //fitness node)
Set RP.Node ← BestRP(1).Node
Set RP.Fitness ← BestFitness(1).Node
End main Func
……………………………………………………………………

FunctionInitialRP(AdjNet, Distance, Src, Dest)
Begin // Generate random node as initial RP node
Set RP←Rnd (Length (AdjNet))
// Repair RP if it belongs to Src or Dest
If Src = RP Or RP belongs to Dest Then
While RP = Src Or RP belongs to Dest Do
RP←Rnd(Length(AdjNet))
        End While
End If
End InitialRP Func
……………………………………………………………………

// find a 2nd candidate RP node and compute fitness value for it
Function Greedy (AdjNet, Distance, Src, Dest, RP)
Begin Set MaxIter ← 100;
ForallIterDo{where 1≤ Iter ≤ MaxIter }
//compute Mutate function to select a new RP
Set ChildRP ← Mutate(AdjNet, Distance, Source, Dest, ParentRP, Iter,MaxIter)
// compute fitness value to evaluate RP node
Set RP ← Fitness(AdjNet, Distance, Src, Dst, RP)
If (ChildRP.Fitness < ParentRP.Fitness) then
ParentRP.Node ←ChildRP.Node
ParentRP.Fitness ← ChildRP.Fitness
RP←ParentRP.Node
Fitnes←ParentRP.Fitness
End //Greedy Func
……………………………………………………………………
// Mutate Func to select a candidate ChildRP
Function Mutate (AdjNet, Distance, Src, Dest, ParentRP, Iter, MaxIter)
Begin // At earlier generations mutate is calculated from whole
// AdjNet, whereas at late generations, mutate is
//calculated from neighborhood nodes
If ((Rnd>= (iter/MaxIter)) Then
Set RP←Rnd (Length (AdjNet))
Else
Set temp ← (Find (ParentRP, *) ==1)
Set child ← Temp (length (AdjNet))
    End if
// Repair RP if it belongs to Src or Dest
If Src = RP Or RP belongs to Dest Then
While RP = Src Or RP belongs to Dest Do
RP←Rnd(Length(AdjNet))
   EndWhile
    EndIf
End Mutate
Func……………………………………………………………………
// compute fitness value to evaluate RP node
Function Fitness (AdjNet, Distance, Src, Dest, RP)
Begin
// set Weight to Src to RP and from RP to Dest based on
// assumed distances
Set wSrc2RP ← 0.5
Set wRP2Dest ← 1- wSrc2RP
// calculate Distance from Src to RP
Set DisSrc2RP ← Distance (Src, RP.Node)
// calculate Distance from RP to Dest
Set DisRP2Dest ← 0
Forall DstCounter Do{where 1≤ DstCounter ≤ length (Dest}
DisRP2Dest ←DisRP2Dest+Distance(RP.Node, Dest (DstCounter)
    End for
// calculate Fitness
RP.Fitness←(wSrc2RP * DisSrc2RP + wRP2Dest*DisRP2Dest)
End Fitness Func
```

To provide fairness as well as to maximize the advantages of multicast among receptors. The design of GRPSA assumes that the expected right RP (of the multicast tree) found close to the middle distance (cost) among the source and receptors. Thus, the RP distance weight set to 0.5 in Fitness function.

Figure 2 to 7 depict the running process of the GRPSA algorithm. It starts by generating a random network topology with 20 nodes (Fig. 2). The symbolic representation of graphs as follows: nodes in the figure denote routers, whereas the directed edges stand for directed links. The initial weights between source to RP and between RP and destination are set to two parameters; wSrc2RP = 0.5, wRP2Dest = 0.5 respectively. Node 11 represents source node (or multicast server) marked with a solid square circle, nodes 2,4,13,14,18 and 20 denote destination nodes, marked with a solid triangle and candidate RP nodes are marked with a solid black circle, child RP denoted by.

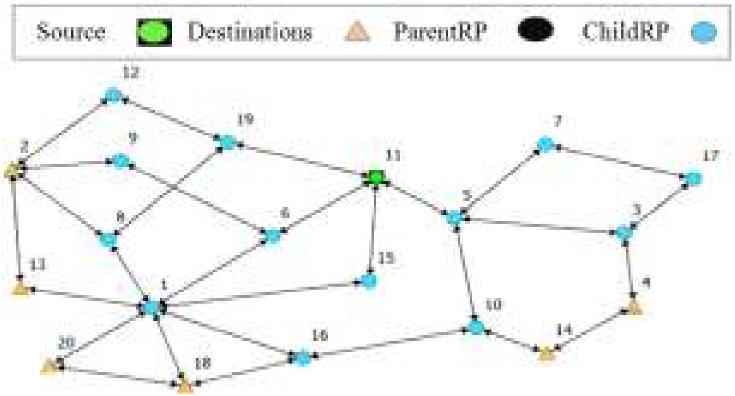


Fig. 2: Initial IPv6 multicast topology

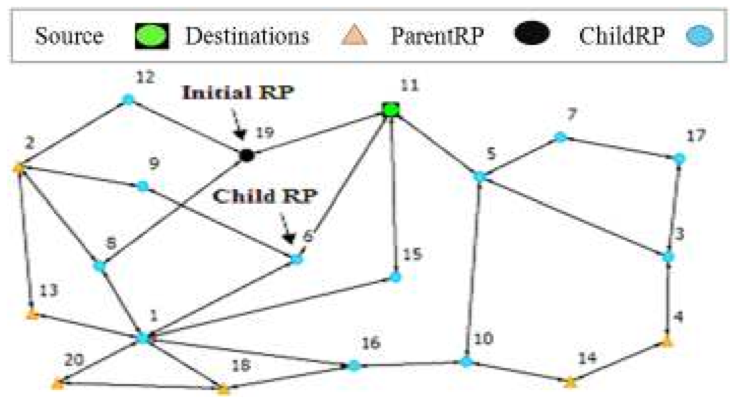


Fig. 3: Nodes (19 and 6) selected as Parent-RP and Child-RP initially and randomly

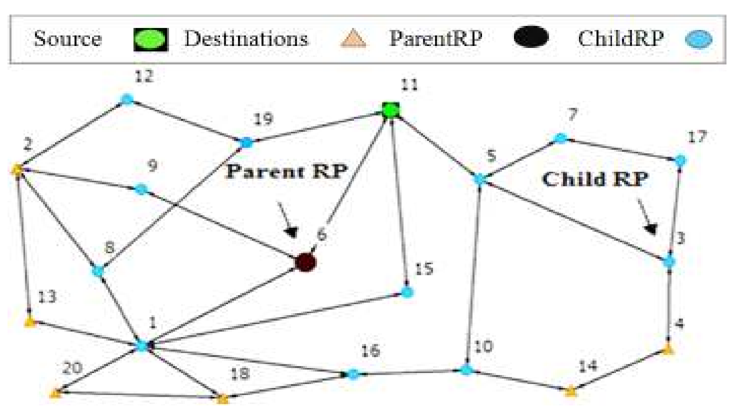


Fig. 4: Node 6 becomes Parent-RP (the less fitness), and node 3 promoted as Child-RP

In Fig. 3, the trace for GRPSA implementation shows that node 19 selected as Parent-RP, then node 6 as Child-RP initially and randomly (represents 1^{st} two rounds). The calculated fitness value for them are (10 and 8.5) respectively using Eq. (1). Through preferring the minimum fitness value, node 6 replaces the current Parent-RP (node 19) and starts the next search which leads to promoting Node 3 as a new Child-RP as illustrated in Fig. 4.

However, the calculated fitness of node 3 was (12) which is greater than node 6 fitness (8.5), so node 3 discarded; as a result, node 6 stays as Parent-RP (Fig. 5). Next, GRPSA search for the next Child-RP node, thus node 16 is selected with calculated fitness value (8). Byfitness comparison, node 16 got Parent-RP vocation temporarily (8 less than 8.5), whereas node 9 promoted as new Child-RP as shown in Fig. 6.

Next, GRPSA greedy algorithm continues discovering all possible Parent-RPs of the topology. Finally, node 1 selected by GRPSA as Native-RP since it has a minimum Fitness value (7) as shown in Fig. 7.

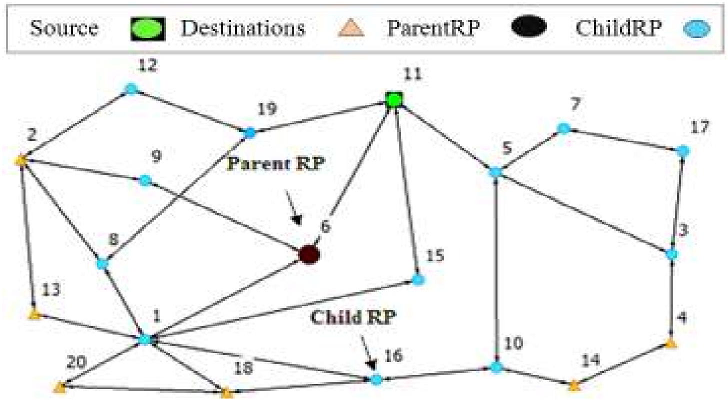


Fig. 5: Illustration node 6 is still RP

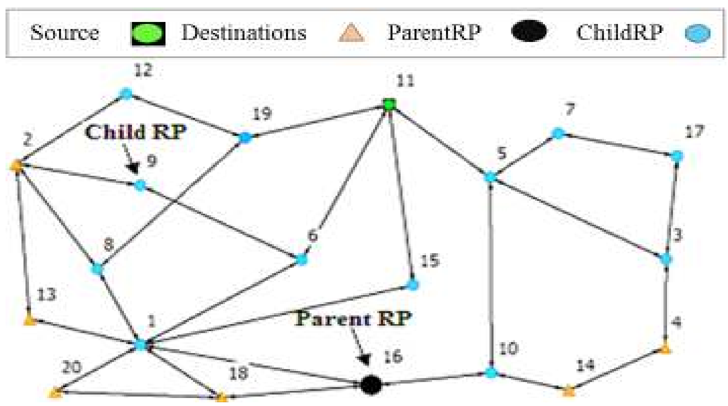


Fig. 6: Node 16 stays as Parent-RP (the less Fitness), Node 9 selected as Child-RP with Fitness (10.5)

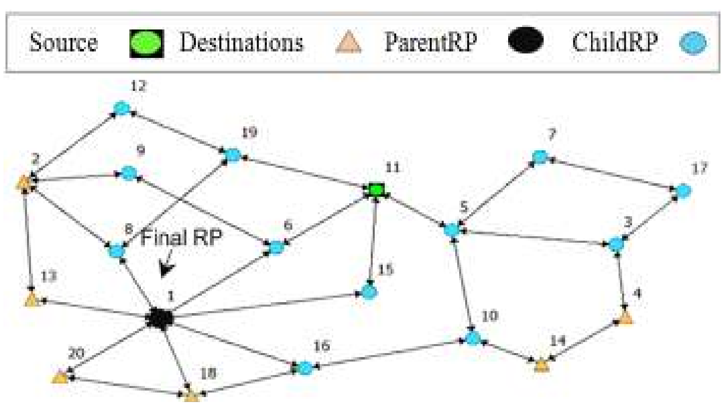


Fig. 7: Node 1 selected as final (Native-RP) with fitness = 7

Table 1. Illustrate the tracking of fitness values for both the Parent and Child RPs per round until node 1 selected as Native-RP represents GRPSA outcome.

GRPSA PERFORMANCE EVALUATION USING GNS3 AND JPERF (QOS VALIDATION)

This section introduces the performance evaluation phase using GNS3 and Jperf. The environment for more complex tested network topology composes 20 virtual Cisco 7200 routers interconnected via serial links as shown in Fig. 8. Six virtual computers realized as VMWARE virtual machines with 1GB RAM and 10GB HDD per virtual machine. End-to-end connection realized using the server as a source for UDP media streaming, then received by clients over theIPv6 multicast network using GNS3. Window 7 is used in virtual machines.

Typically, PIM-SM Multicast protocol depends on unicast routing table to perform the reverse path

Table 1: Trace for GRPSA rounds to select the best RP based on fitness using Eq. 1 (Multicast topology in Fig. 2 to 7)

	Parent-RP		Child-RP	
GRPSA Alg. round	Node no.	Fitness	Node no.	Fitness
Initial round	19	10	-	-
Round 1	19	10	6	8.5
Round 2	6	8.5	3	12
Round 3	6	8.5	16	8
Round 4	16	8	9	10.5
Round 5	16	8	1	7
Round 6	1	7	15	9
Round 7	1	7	8	9
Round 8	1	7	7	13.5
Round 9	1	7	5	10
Round 10	1	7	17	15.5
Round 11	1	7	12	11.5
Round 12	1	7	10	8.5
Alg. Stop	1	7	-	-

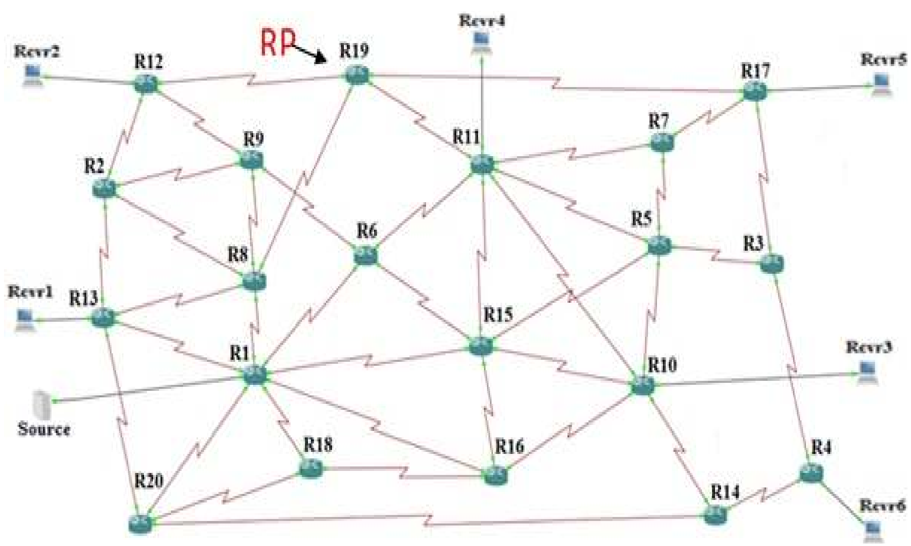


Fig. 8: IPv6 multicast network topology (one source and six receivers) using UDP streaming over GNS3 and JPERF

forwarding (RPF) check, which identifies the closest interface of the multicast router to the source. Thus, OSPF unicast protocol is used in the tested topology. The GNS3setting and configuration steps for the tested IPv6-multicast network topology are listed as follows:

Enable IPv6 and Multicast routing:

- **Enable IPv6 Unicast routing:**

  Router (config) # IPv6 unicast-routing

- **Enable multicast:**

  Router (config) #IPv6 multicast routing

- **Configure OSPF unicast protocol:**

The following two configuration commands represent OSPF unicast routing protocol activated in Router 1as a requirement of IPv6 PIM-SM protocol.

Router1 (config) # IPv6 routing ospf <1-65535> process id
Router1 (config-router) # router-id 1.1.1.1

Moreover, the configuration commands (fragment) of IPv6 addressing, OSPF and clock rate for Router 1 interfaces (serial and Ethernet) looks like:

Router1 (config) # interface fast Ethernet 0/0
Router1 (config-if) # IPv6 add 2001:1111:: 1/64
Router1 (config-if) # no shut
Router1 (config-if) # IPv6 ospf 1 area 0
Router1 (config) # interface serial 2/0
Router1 (config-if) # IPv6 add 2001:2222::1/64
Router1 (config-if) # no shut
Router1 (config-if) # clock rate 1612800
Router1 (config-if) # IPv6 ospf 1 area 0
Router1 (config) # interface loopback 0
Router1 (config-if) # IPv6 add 2001:DB8:1::1/64
Router1 (config-if) # IPv6 ospf 1 area 0
Router1 (config) # interface serial 2/1
Router1 (config-if) # IPv6 add 2001:5555::1/64
Router1 (config-if) # no shut
Router1 (config-if) # clock rate 1612800
Router1 (config-if) # IPv6 ospf 1 area 0

Configure IPV6 PIM-SM: RP in PIM-SM acts as shared root between source and receiver of multicast data streaming. Typically, RP can configure in multicast IPv6 using three ways; static-RP, Embedded-RP, or BSR-RP. The core design for all of these ways does not care or irresponsive of best RP selection. The focus of this study on is priority-based BSR-RP configuration. Basically, candidate-BSR router selected randomly and configured manually indoors of the multicast network. Where the Candidate-BSR with highest-priority must elect, which in turn informs the rest routers of the network using BSM (Bootstrap message) to response once any of them configured as candidate-RP. Also, candidate RPs are selected randomly and configured manually.

Furthermore, the job of the selected BSR is to distribute information among candidate-RPs inside the network using BSM (such as RP address, priority, group IPv6 address and a hash mask length between 0-128 for IPv6). Finally, all network routers use a hash function to select the native-RP under the control of BSR. However, most probably the process outcomes a native-RP that is not the right RP selection. For that, it is expected that the proposed algorithm GRPSA may well contribute and stretch the BSR job for better or optimum Native-RP selection.

For example, the Configuration steps for two candidates as BSR and RP with their priority are defined bellow respectively:

- **Configuration command for Candidate-BSR with priority 20:**

  Router (config) # ipv6 pimbsr candidate bsr<Candidate-BSR IPv6 address> priority 20

- **Configuration command for Candidate-RP with priority 5:**

  Router (config) # ipv6 pimbsr candidate RP <Candidate-RP IPv6 address>priority 5

Configure IPv6 MLD-join multicast group: Since IPv6 is activated in the tested multicast topology. Each router-interface connected to the multicast receiver must configure with MLD (multicast listener discovery) protocol to understand the join or leave commands within the multicast group. The configuration command for MLD is:

Router (config-if) # IPv6 MLD join-group FF08:8::1

Deployment of Jperf traffic generator for QoS validation: The Source denoted in Fig. 8 is configured as a multicast source (server) for UDP traffic streaming received by the rest Receivers (Receivers: 1-6), all configured as a multicast group (Fig. 8). Jperf server generates CBT/UDP multicast traffic that passes through theGNS3 core network and then received by Jperf receivers at the other end of the network. Jperf setting parameters conclude UDP bandwidth which set to 700 kbps, TTL set to 128 and the IPv6-multicast group set to FF08:8::1. The main concern is how to evaluate the QoS metrics for different cases of RP selection compared to or validates GRPSA-RP selection.

RESULTS AND DISCUSSION

The keynote that characterizes the current research is that it focuses on the fact, which says the output of any available RP selection algorithms would be one of the possible RPs within a multicast network under investigation. For the sake of performance, evaluation and competition among other developed RP selection algorithms, the authors of current research believe that the results should compare using two factors. The first compare it to the optimally calculated RP selection, whereas the second should compare it to the average of all possible RPs (which may choose by whatever RP selection algorithms).

The result obtained from six receivers and one source for the same multicast group through a 5-minutes period (Table 2 and 3). The tested IPv6 multicast topology composes 20 routers except for the source and receivers. Table 2 shows the setting of server side for the generated UDP streaming traffic. Since GRPSA promoted router 19 as Native-RP or best RP selection using MATLAB. Table 3 shows the effect of selecting RP by GRPSA algorithm compared to the average of rest possible RPs in terms of the data received (Total throughput)in KB, Bandwidth (Average)in kbps, jitter in ms and the percentage of lost datagrams over the total sent datagrams. The traffic comparison covers the six receivers from one multicast source. When GRPSA-RP considered (Node 19), it was noted that receiver no. 5 got the maximum traffic support (data received is 23590 out of 24881 KB with 5.2% loss) compared to the less received traffic by receiver 6 (received 19611 out of 24881 KB with 21% loss). Whereas when the average received traffic of the other possible RPs is considered, it was found that the maximum advantage in receiving UDP streaming got at got at receiver 3 (received 18001 out of 23907 KB with 25% loss) compared to the less traffic received at receiver 6 (15150 out of 23907 KB with 37% loss). The variation in data received due to the difference in path distances from the RP to each receiver including the no. of hops.

Table 2: Server side (source)

Source	RP	Transfer (KB)	Bandwidth (kbps)	Sent data grams
Source	Native-RP using GRPSA (node 19)	24881	679	17382
	Average of rest RPs	23907	653	16654

Table 3: Receivers side (Receivers 1 -6)

Receiver	RP	Data Received (KB)	Bandwidth (kbps)	Jitter (ms)	(Lost/ Datagram)
Rcvr1	GRPSA-RP Node 19	22125	604	28.65	11 %
	Avg. of rest RPs	17208	469	49.08	28 %
Rcvr2	GRPSA-RP Node 19	23556	643	12.94	5.3 %
	Avg. of rest RPs	16421	448	33.93	31 %
Rcvr3	GRPSA-RP Node 19	19989	545	19.99	20 %
	Avg. of rest RPs	18001	491	32.04	25 %
Rcvr4	GRPSA-RP Node 19	23079	630	24.1	7.2 %
	Avg. of rest RPs	15596	425	43.05	35 %
Rcvr5	GRPSA-RP Node 19	23590	644	13.98	5.2 %
	Avg. of rest RPs	16334	445	34.76	32 %
Rcvr6	GRPSA-RP Node 19	19611	535	25.57	21 %
	Avg. of rest RPs	15150	413	39.70	37 %

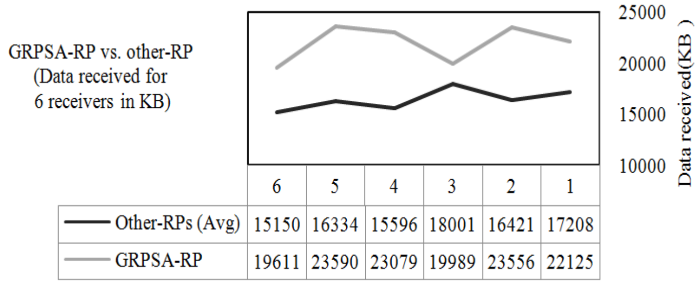


Fig. 9: GRPSA-RP vs. other-RPs (Data received for 6 receivers in KB)

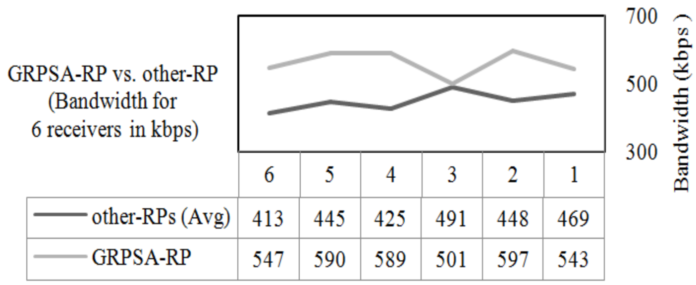


Fig. 10: GRPSA-RP vs. other-RPs (Throughput for 6 receivers in kbps)

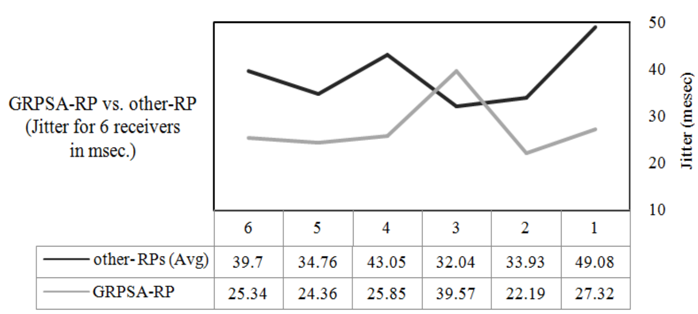
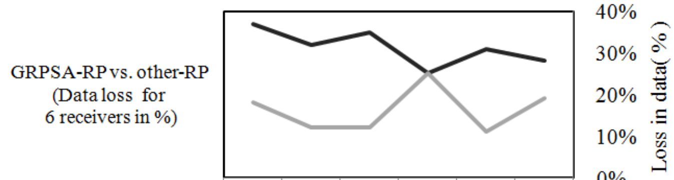


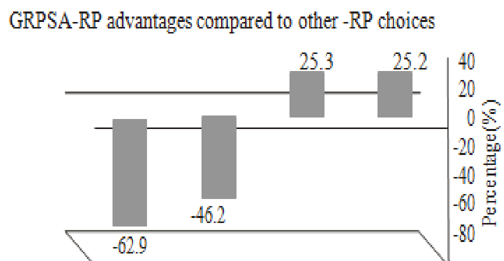
Fig. 11: GRPSA-RPs vs. other-RPs (Jitter for 6 receivers in msec.)

Figure 9 to 12 show the results summary for the comparison between GRPSA-RP selection compared to the average results for the rest RP selection in terms of QoS parameters represented by data received (Total throughput), Bandwidth (Average), jitter and datagramloss respectively. The results in all tested QoS parameters shows GRPSA-RP wins the average of the rest possible RPs.



	6	5	4	3	2	1
other-RPs (Avg)	37%	32%	35%	25%	31%	28%
GRPSA-RP	18%	12%	12%	25%	11%	19%

Fig. 12: GRPSA-RP vs. other-RPs (Data loss for 6 receivers using %)



	Datagram Loss	Jitter	Bandwidth	Data Received
GRPSA-RP Advantages	-62.9	-46.2	25.3	25.2

Fig. 13: GRPSA-RP vs. other-RPs) based on the four QoS metrics for 6 receivers (on average as %)

Figure 13 shows GRPSA-RP versus other-RPs based on the four QoS metrics for 6 receivers (on average). The noticed gain in Jitter (decreased up to 46.2%) with less datagram loss (decreased up to 62.9%). Both contributed to the increase of data received (Total throughput) at the 6 receivers on average (25.2%) with average bandwidth up to (25.3%).

CONCLUSION

This study introduced a new deployment for IPv6 greedy algorithm called GRPSA based on Fitness criteria to solve RP-selection problem for theIPv6 multicast domain. This minimization problem considered as an NP-complete problem that requires further research investigation. The MATLAB implementation test of the proposed algorithm (GRPSA) depicts the behavior and calculation for finding the best or Native-RP choice among other possible RPs. This choice validated using GNS3 supported with Jperf based on QoS metrics. It is found that the right selection of RP router is very significant due to the direct impact on the tree structure rooted by RP. Furthermore, it affects the performance of multicast routing protocol. Consequently, the received quality and quantity of multicast streaming traffic shows variations in data received(Total throughput),Bandwidth (Average),jitter anddatagram loss, with the distinguished result using GRPSA-RP comparatively. Finally, to save the cost calculations, it could mix the GRPSA target in selecting the best RP for IPv6 multicast with anexisting routing protocol such as OSPF as future work.

REFERENCES

Baddi, Y. and M.D.E.C. El Kettani, 2012. VNS-RP algorithm for RP selection in multicast routing protocol PIM-SM. Proceeding of the IEEE International Conference on Multimedia Computing and Systems (ICMCS).

Baddi, Y. and M.D.E.C. El Kettani, 2013. Parallel GRASP algorithm with delay and delay variation for core selection in shared tree based multicast routing protocols. Proceeding of the IEEE 3rd International Conference on Innovative Computing Technology (INTECH).

Ballardie, A., 1997. Core Based Trees (CBT version 2) multicast routing--protocol specification. Inter-Domain Multicast routing, 1997 InternetDraft,<draft-ietf-idmr-cbt-spec-v2.txt.

Bartczak, T. and P. Zwierzykowski, 2009. Validation of PIM DM and PIM SM protocols in the NS2 network simulator. Proceeding of the IEEE AFRICON 2009.

Bartczak, T. and P. Zwierzykowski, 2012. Performance evaluation of source-specific multicast routing protocols for IP networks. Proceeding of the 8th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP).

Bhaskar, N., A. Gall,J. Lingard and S. Venaas, 2008. Bootstrap Router (BSR) mechanism for Protocol Independent Multicast (PIM). Network Working Group.

Bilicki, V., 2006. Testing and verifying an ipv6 based multicast network. Proceeding of the IEEE International Multi-Conference on Computing in the Global Information Technology (ICCGI'06).

Eiben, A.E. and J.E. Smith, 2015. Introduction to Evolutionary Computing. 2nd Edn., Springer-Verlag, Berlin, Heidelberg.

Fenner, B., M. Handley, H. HolbrookandI. Kouvelas, 2006. Protocol independent multicast-sparse mode (PIM-SM): Protocol specification (revised). Network Working Group, Retrieved from: https://tools.ietf.org/html/rfc4601.

Gendreau, M. and J.Y. Potvin, 2010. Handbook of Metaheuristics. 2nd Edn., Springer, New York.

Joseph, V. and S. Mulugu, 2011. Deploying Next Generation Multicast-enabled Applications: Label Switched Multicast for MPLS VPNs, VPLS and Wholesale Ethernet. 1st Edn., Morgan Kaufmann, Waltham, MA.

Lloret, J., M. Garcia, A. Canovas and C. Turro, 2011. A stereoscopic video transmission algorithm for an IPTV network based on empirical data. Int. J. Commun. Syst., 24(10): 1298-1329.

Mehlhorn, K., 1988. A faster approximation algorithm for the Steiner problem in graphs. Inform. Process. Lett., 27(3): 125-128.

Taqiyuddi, A., M.Z. Arifin, A.H. Abdalla, F. Anwar and S. Al-Irhayim, 2008. A comparative study of source specific multicast and aggregated source specific multicast. Proceeding of the IEEE International Conference on Computer and Communication Engineering (ICCCE, 2008).

Wang, H., X. Meng, M. Zhang and Y. Li, 2010. Tabu search algorithm for RP selection in PIM-SM multicast routing. Comput. Commun.,33(1): 35-42.

Zappala, D., A. Fabbri and V. Lo, 2002. An evaluation of shared multicast trees with multiple cores. Telecommun. Syst., 19(3-4): 461-479.