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Design of a high efficiency addressing model for IPv6 Networks via bioinspired computing

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***Abstract*—**

IPv6 Networks require efficient addressing schemes that must ensure location-awareness for higher energy efficiency under different network conditions. To perform this task, a large number of QoS (Quality of Service) aware addressing models are discussed by researchers, but most of these models adopt a static processing method for addressing, which limits their scalability for large sized networks. Models that support dynamic addressing are very complex to implement, and thus reduce QoS performance for large-scale networks. To overcome these limitations, this text proposes design of a novel high efficiency addressing model for IPv6 Networks via Genetic Algorithm based optimization techniques. The proposed model uses node locations, and energy levels to identify base addressing & sub netting schemes. These schemes are evaluated in terms of transmission energy levels, reception energy levels, and distance between frequently communicating nodes. Based on this evaluation, the model is able to identify similar subnet addresses for nearby nodes that have similar energy signatures. This assists in formation of node clusters, and improving its addressing efficiency under different scenarios. The model was tested under small, medium & large-scale networks, and its addressing efficiency levels were observed. Based on this observation, it was concluded that the proposed model showcased 10.3% lower energy consumption, 8.5% better speed, and 15.4% higher addressing efficiency when compared with other state-of-the-art addressing models. Due to this increase in performance, the proposed model is capable of deployment for large-scale IPv6 Networks.

Keywords-component; IPv6, Addressing, Genetic, Algorithm, Energy, Distance, Efficiency, Speed

1. INTRODUCTION

Address assignment for IPv6 Networks is a multidomain task that involves design of location-aware address evaluation, with continuous network monitoring & performance optimization tasks. A typical IPv6 addressing model flow is depicted in figure 1, wherein core routers are initially assigned routing prefix-based addresses, which are extended by region-based router nodes for subnetting, and finally interface identifiers (IDs) are assigned to client nodes. Due to this 3-step addressing scheme, it is easier for routers to identify nearby nodes for low-power and high-speed routing performance. To design such addressing schemes, it is necessary that routing prefixes must be assigned to nodes that have higher proximity. Similar operations must be performed while assigning subnet addresses, which assists in simplified identification of nearby access nodes during the routing process [1].

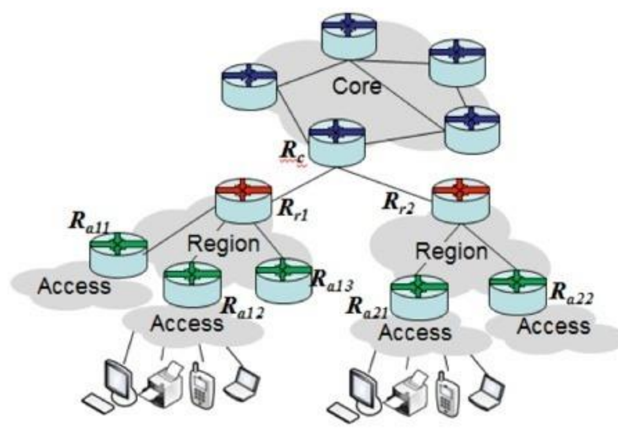

Figure 1. A typical IPv6 Address Assignment Model Flow

Based on these operations, various addressing models are proposed by researchers and each of these models vary in terms of computational delay, energy efficiency, applicability, and other performance metrics. An Internet Control Message Protocol (ICMP) based IPv6 addressing model is depicted in figure 2, wherein communication between a personal computing (PC) Node, and Router is depicted via switching devices.

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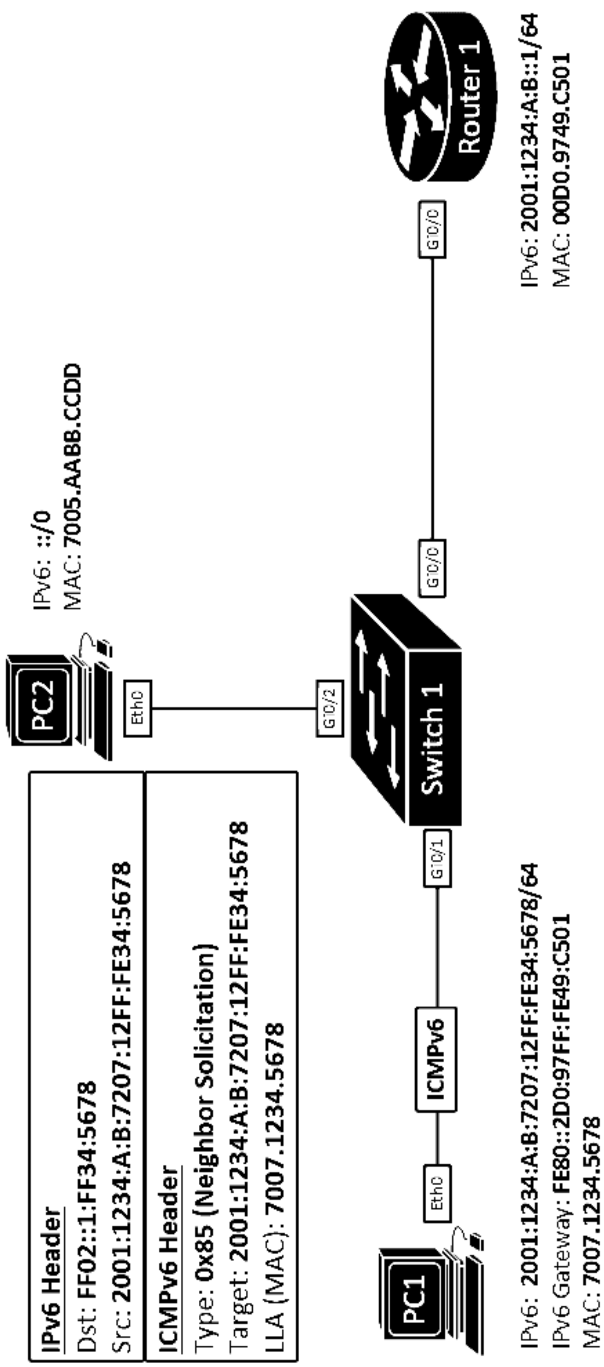

Figure 2. Communication between PC to Router via Switch based on IPv6 Addressing

In the model, a PC initially defines an IPv6 header, and an ICMPv6 header, which is passed through a switching device for communication checks. These checks involve identification of IPv6 subnet address, extraction of routing address, and evaluation of network IDs. These IDs are passed to the router for packet verification, which assists in either passing or blocking various communication requests. Similar models [2, 3, 4], along with their nuances, advantages, limitations, and future research scopes are discussed in the next section of this text. Based on this discussion it was observed that most of these models adopt a static processing method for addressing, which limits their scalability for large sized networks. Models that support dynamic addressing are very complex to implement, and thus reduce QoS performance for large-scale networks. To overcome these limitations, section 3 proposes design of a novel high efficiency addressing model for IPv6 Networks via Genetic Algorithm based optimization techniques. The proposed model was evaluated under different network conditions, and its performance was estimated in section 4 of this text. Finally, this text concludes with some interesting observations about the proposed model, and recommends methods to further improve its performance.

2. LITRATURE REVIEW

A wide variety of addressing schemes are proposed by researchers for IPv6 addressing, for instance, work in [2, 3, 4] proposes use of TGAs-based IPv6 address scanning, IPv6 Hitlist and Efficient Probing of IPv6 Addresses, and DetNet based models. These models assist in improving addressing efficiency by reducing performance overheads on nodes. Similar models are proposed in [5, 6] wherein use of address encryption and verification schemes, and density space tree (DST) for overall performance optimizations. These optimizations are further extended via the work in [7] wherein, researchers have proposed use of different routing protocols to improve efficiency of addressing schemes. This model is used by work in [8, 9, 10] for Explicit Address Mapping Table (EAMT) generation, XMap based scanning, and Geographical Addressing Management for Satellite (GAMS) which have application specific performance constraints. These constraints are removed via use of Reinforcement Learning (RL) [11], Cloud based processing [12] Generative Adversarial Nets with Reinforcement Learning (GAN RL) [13], and exploration of Transition Mechanisms [14] under large scale scenarios. Similar models are discussed in [15, 16], wherein use of Telescope Network Traffic Overview, and Addressless security models are proposed by researchers. But most of the reviewed models adopt a static processing method for addressing, which limits their scalability for large sized networks. To overcome this limitation, next section proposes design of high efficiency addressing model for IPv6 Networks via bioinspired computing, and evaluates its performance under different network scenarios.

3. PROPOSED DESIGN OF HIGH EFFICIENCY ADDRESSING MODEL FOR IPV6 NETWORKS VIA BIOINSPIRED COMPUTING

Based on the literature review, it can be observed that most of the reviewed models adopt a static processing method for addressing, which limits their scalability for large sized networks. Models that support dynamic addressing are very

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complex to implement, and thus reduce QoS performance for large-scale networks. To overcome these limitations, a novel GA based IPv6 Addressing Model is depicted in figure 2, wherein QoS evaluation along with GA deployment processes can be observed. The model initially evaluates current QoS levels of the network, and based on these levels, estimates different mutation and crossover operations for selection of best addressing scheme for current network deployment.

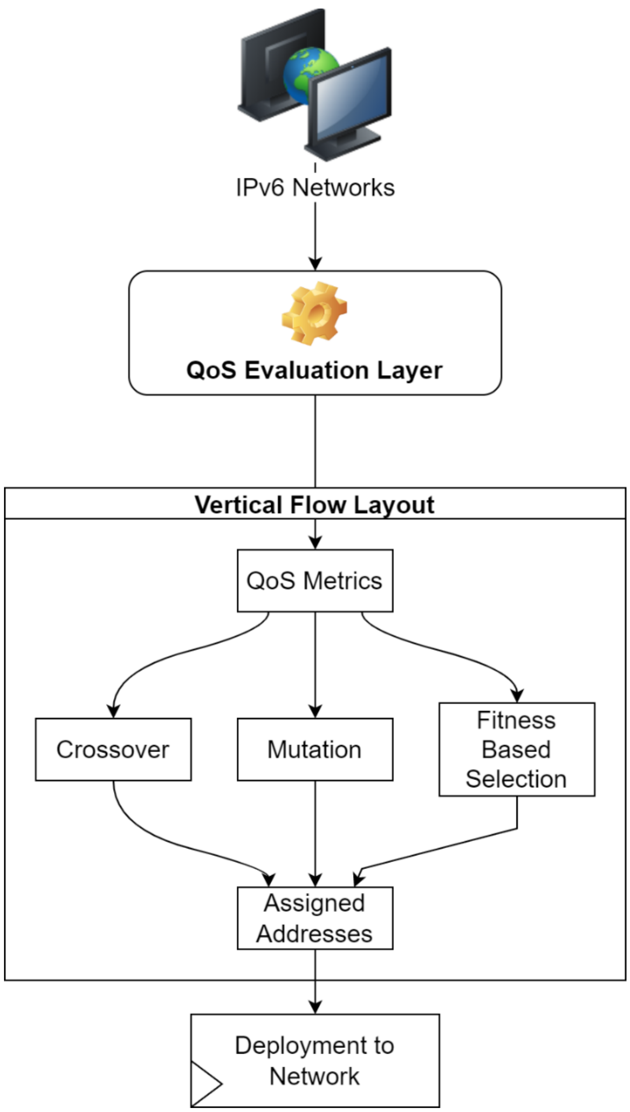

Figure 2. Design of the proposed model for IPv6 addressing in real-time networks

The GA Model works via the following process,

- Initialize GA Parameters,
  - Total iterations (N_i)
  - Total solutions (N_s)
  - Rate at which the model learns (L_r)
- Identify locations & energy levels of all deployed nodes.
- Initially mark all solutions as 'to be modified'
- For each iteration in 1 to N_i
  - For each solution in 1 to N_s
    - If the solution is marked as 'not to be modified', then go to the next solution and check its modification status
    - Else, generate a new solution via the following process,
      - Stochastically identify new node addresses based on their location, and perform N communications based on these addresses
      - Evaluate fitness level of solution via equation 1,

$$f = \frac{\sqrt{\left(dest(x) - src(x)\right)^2 + \left(dest(y) - src(y)\right)^2}}{src(Energy) + dest(Energy)} \ldots (1)$$

      - Evaluate this fitness for all node addresses, and generate different solutions
    - At the end of current iteration, identify iteration fitness threshold via equation 2 as follows,

$$f_{th} = \sum_{i=1}^{N_s} f_i * \frac{L_r}{N_s} \ldots (2)$$

    - Mark solutions as 'to be modified' if $f \geq f_{th}$, else mark them as 'not to be modified'
  - Repeat this process for all iterations, and select solution with minimum fitness

The selected solution consists of addressing schemes for different nodes, which can be used for low distance and high energy efficiency operations. This efficiency was evaluated for different network deployments, and compared with various state-of-the-art models in the next section of this text.

4. RESULT & COMPARISON

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The proposed model uses Genetic Algorithm for estimation of IPv6 addresses under different network conditions. In order to evaluate performance of the model, it is compared with the standard addressing models as proposed in Det Net [4], DST [6], and RL [11]. These networks are evaluated under different network types, and under different networking scenarios. Using standard network and node configuration, the number of node communications (NC) were varied linearly between 20 and 400; and same nodes were selected for routing across each run. While performing node communications, average QoS values for energy consumption (E), end-to-end communication delay (D), packet delivery ratio (PDR), and throughput (T) were evaluated. As per this evaluation process, values for end-to-end delay (D) for different protocols is tabulated in table 1 as follows,

NC	D (ms) Det Net [4]	D (ms) DST [6]	D (ms) RL [11]	D (ms) Proposed
20	0.78	0.89	0.97	0.57
40	0.86	0.96	1.06	0.62
60	0.93	1.03	1.11	0.66
80	0.96	1.07	1.16	0.68
100	1.00	1.13	1.23	0.72
120	1.07	1.20	1.33	0.79
150	1.13	1.34	1.55	0.94
180	1.33	1.75	2.01	1.22
200	1.87	2.29	2.53	1.50
240	2.32	2.61	2.84	1.67
260	2.46	2.79	3.08	1.83
280	2.67	3.14	3.48	2.07
300	3.10	3.60	3.93	2.32
350	3.49	3.95	4.36	2.59
380	3.76	4.49	4.94	2.83
400	4.12	5.05	5.49	3.06

Table 1. Average end-to-end delay for different addressing models

It can be observed that delay was reduced by almost 18.5% when compared to other models. Which is due to incorporation of GA, which assists in delay-aware addressing mechanisms. Similar observations are done for energy performance, this can be observed from table 2 as follows,

NC	E (mJ) Det Net [4]	E (mJ) DST [6]	E (mJ) RL [11]	E (mJ) Proposed
20	1.79	2.89	2.60	1.57
40	2.19	3.25	2.86	1.72
60	2.29	3.40	3.01	1.81
80	2.40	3.60	3.19	1.92
100	2.55	3.83	3.38	2.03
120	2.72	4.03	3.54	2.12
150	2.82	4.19	3.68	2.21
180	2.94	4.35	3.82	2.30
200	3.05	4.51	3.98	2.40
240	3.15	4.75	4.23	2.55
260	3.37	5.16	4.56	2.74
280	3.72	5.45	4.73	2.83
300	3.88	5.56	4.83	2.89
350	3.95	5.75	5.02	3.01
380	4.11	5.97	5.21	3.12
400	4.27	6.19	5.39	3.23

Table 2. Average energy consumption for different addressing models

It can be observed that energy consumption was reduced by almost 14.8% when compared to other models. Which is due to incorporation of GA, which assists in energy-aware addressing mechanisms. Similar observations are done for throughput performance, and can be observed from table 3 as follows,

NC	T (kbps) Det Net [4]	T (kbps) DST [6]	T (kbps) RL [11]	T (kbps) Proposed
20	262.27	274.04	316.94	377.60
40	265.30	276.21	319.28	380.33
60	266.39	277.93	321.48	383.14
80	268.56	280.44	324.37	386.65
100	271.22	283.01	327.26	390.08

120	273.52	285.39	330.08	393.36
150	275.82	287.76	332.90	396.63
180	278.12	290.14	335.65	399.91
200	280.42	292.51	338.40	403.18
240	282.72	294.89	341.15	406.46
260	285.02	297.27	343.90	409.74
280	287.32	299.71	346.65	413.01
300	289.61	302.15	349.40	416.29
350	291.91	304.53	352.15	419.56
380	294.21	306.84	354.86	422.79
400	296.51	309.16	357.57	426.01

Table 3. Average throughput performance for different addressing models

It can be observed that throughput was increased by almost 28.3% when compared to other models. Which is due to incorporation of GA, which assists in throughput-aware addressing mechanisms. Similar observations are done for packet delivery rate (P) performance, and can be observed from table 4 as follows,

NC	**PDR (%) Det Net [4]**	**PDR (%) DST [6]**	**PDR (%) RL [11]**	**PDR (%) Proposed**
20	76.68	76.45	77.31	86.30
40	77.57	77.04	77.88	86.93
60	77.89	77.52	78.41	87.56
80	78.53	78.22	79.13	88.35
100	79.31	78.95	79.84	89.14
120	79.97	79.61	80.51	89.90
150	80.64	80.27	81.18	90.64
180	81.32	80.94	81.85	91.39
200	81.99	81.61	82.53	92.14
240	82.66	82.27	83.20	92.90
260	83.33	82.94	83.87	93.64
280	84.01	83.61	84.55	94.39
300	84.68	84.27	85.22	95.14
350	85.35	84.94	85.89	95.90
380	86.02	85.61	86.56	96.65
400	86.70	86.26	87.22	97.39

Table 4. Average packet delivery ratio performance for different addressing models

It can be observed that PDR was increased by almost 10.5% when compared to other models. Which is due to incorporation of GA, which assists in PDR-aware addressing mechanisms. Based on these results it can be observed that the proposed model is highly efficient in terms of end-to-end delay, communication throughput, energy efficiency, and packet delivery ratio when compared with other standard models.

5. CONCLUSION

The proposed model uses a combination of GA with stochastic modelling to assign energy aware and delay aware addresses to different nodes. Due to this combination, it was observed that delay was reduced by almost 18.5% when compared to other models, it was also observed that energy consumption was reduced by almost 14.8%, throughput was increased by almost 28.3%, and PDR was increased by almost 10.5% when compared to other models. This is due to incorporation of GA, which assists in delay & energy aware addressing mechanisms under different network conditions. In future, researchers can also incorporate different bioinspired models including Particle Swarm Optimization (PSO), Grey Wolf Optimization (GWO), etc. to further improve network performance. Furthermore, researchers can also integrate deep learning techniques like Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), etc. to develop parameter aware addressing models that work under different scenarios.

6. REFERENCE

[1] A. K. Al-Ani, M. Anbar, A. Al-Ani and D. R. Ibrahim, "Match-Prevention Technique Against Denial-of-Service Attack on Address Resolution and Duplicate Address Detection Processes in IPv6 Link-Local Network," in IEEE Access, vol. 8, pp. 27122-27138, 2020, doi: 10.1109/ACCESS.2020.2970787.

[2] G. Zheng, X. Xu and C. Wang, "An Effective Target Address Generation Method for IPv6 Address Scan," 2020

IEEE 6th International Conference on Computer and Communications (ICCC), 2020, pp. 73-77, doi: 10.1109/ICCC51575.2020.9345025.

[3] G. Song et al., "Towards the Construction of Global IPv6 Hitlist and Efficient Probing of IPv6 Address Space," 2020 IEEE/ACM 28th International Symposium on Quality of Service (IWQoS), 2020, pp. 1-10, doi: 10.1109/IWQoS49365.2020.9212980.

[4] M. Wang and D. Yang, "IPv6 Address Assignment and Management Mechanism for Heterogeneous Industrial Networks," 2021 IEEE 5th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC), 2021, pp. 2116-2121, doi: 10.1109/IAEAC50856.2021.9390810.

[5] L. Zhen and K. Ma, "Encryption and verification scheme of source IPv6 address between Internet domains," 2021 2nd International Conference on Computer Communication and Network Security (CCNS), 2021, pp. 126-133, doi: 10.1109/CCNS53852.2021.00032.

[6] G. Song et al., "DET: Enabling Efficient Probing of IPv6 Active Addresses," in IEEE/ACM Transactions on Networking, doi: 10.1109/TNET.2022.3145040.

[7] R. Pal, R. Kushwaha, R. S. Tomar and R. Tripathi, "Comparison of Three Routing Protocols in terms of Packet Transfer Using IPv6 Addressing," 2021 8th International Conference on Smart Computing and Communications (ICSCC), 2021, pp. 164-169, doi: 10.1109/ICSCC51209.2021.9528111.

[8] Y. Toyota and O. Nakamura, "Dynamic Control Method of Explicit Address Mapping Table in IPv6 Single-Stack Network," 2020 21st Asia-Pacific Network Operations and Management Symposium (APNOMS), 2020, pp. 37-42, doi: 10.23919/APNOMS50412.2020.9237034.

[9] X. Li, B. Liu, X. Zheng, H. Duan, Q. Li and Y. Huang, "Fast IPv6 Network Periphery Discovery and Security Implications," 2021 51st Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN), 2021, pp. 88-100, doi: 10.1109/DSN48987.2021.00025.

[10] Y. Chen, H. Li, J. Liu, Q. Wu and Z. Lai, "GAMS: An IP Address Management Mechanism in Satellite Mega-constellation Networks," 2021 International Wireless Communications and Mobile Computing (IWCMC), 2021, pp. 229-234, doi: 10.1109/IWCMC51323.2021.9498722.

[11] B. Hou, Z. Cai, K. Wu, J. Su and Y. Xiong, "6Hit: A Reinforcement Learning-based Approach to Target Generation for Internet-wide IPv6 Scanning," IEEE INFOCOM 2021 - IEEE Conference on Computer Communications, 2021, pp. 1-10, doi: 10.1109/INFOCOM42981.2021.9488794.

[12] L. Lin, "Research and Analysis on Key Technologies of Cloud Computing Platform Based on IPv6," 2020 IEEE International Conference on Power, Intelligent Computing and Systems (ICPICS), 2020, pp. 181-183, doi: 10.1109/ICPICS50287.2020.9202056.

[13] T. Cui, G. Gou, G. Xiong, C. Liu, P. Fu and Z. Li, "6GAN: IPv6 Multi-Pattern Target Generation via Generative Adversarial Nets with Reinforcement Learning," IEEE INFOCOM 2021 - IEEE Conference on Computer Communications, 2021, pp. 1-10, doi: 10.1109/INFOCOM42981.2021.9488912.

[14] J. Tang, "Research on IPv6 Protocol Transition Mechanism," 2021 6th International Conference on Intelligent Computing and Signal Processing (ICSP), 2021, pp. 702-705, doi: 10.1109/ICSP51882.2021.9408680.

[15] C. Liu, S. Hao, Q. Liu, C. Bao and X. Li, "IPv6-Network Telescope Network Traffic Overview," 2021 IEEE 11th International Conference on Electronics Information and Emergency Communication (ICEIEC)2021 IEEE 11th International Conference on Electronics Information and Emergency Communication (ICEIEC), 2021, pp. 1-4, doi: 10.1109/ICEIEC51955.2021.9463724.

[16] R. Liu, Z. Weng, S. Hao, D. Chang, C. Bao and X. Li, "Addressless: Enhancing IoT Server Security Using IPv6," in IEEE Access, vol. 8, pp. 90294-90315, 2020, doi: 10.1109/ACCESS.2020.2993700.

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