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Improving Handoff Decisions for Heterogeneous High Speed Networks Using Deep Learning

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***Abstract*—**Presence of multiple networks in a particular area is a very common real time scenario, due to this there is a presence of multiple service providers which can serve a particular node's communication needs. Taking a handoff decision in such a complicated heterogeneous network scenario is tricky at both node and network level, as the nodes demand higher QoS while the network demands optimum number of nodes for service. To solve this complex problem, we propose a deep learning based approach which minimizes the false handoffs in the network, and reduces the delay needed during the handoff procedure. Our observations show that there is a 10% reduction of number of unnecessary handoffs in the network, and more than 8% reduction in handoff decision delay as compared to the existing game theory based algorithms.

***Keywords*—** Heterogeneous, handoff, deep learning, QoS, delay

I. INTRODUCTION

Introduction The handoff decision process is fundamental for giving longer availability to moving nodes in a remote system. The system cell-structure which is generally helical fit as a fiddle, is associated with atmost 6 neighboring cells, which settles the quantity of headings the client can take while moving in the system. These headings help the handoff decision unit (HDU) to recognize the cell or system in which handoff should be possible [1]. The HDU likewise contemplates the system parameters, the node's developments, node's interior parameters, and system to node connected parameters and by and large system structure so as to grasp the handoff decisions. The handoff procedure is performed utilizing the accompanying advances [2],

- Network parameter examining
- Node parameter examining
- Parameter combination
- Application of handoff rules
- Actual handoff process

At first the system parameters like transmission capacity of the system, cost per unit information exchange, information rate, inclusion of the system and others are checked by the HDU and are investigated on a for each system premise [3]. When these system parameters are filtered, at that point the node parameters like received signal strength indicator (RSSI) [4], signal to noise ratio (SNR) [5], the enthusiasm of the node in a specific system (the node's enthusiasm for a specific system can be induced from the home area enroll or the guest area enlist of the system, and from the node's system inclusion or whatever other customized parameter which is favored by the system architect that does not cover other factual parameters), the connection nature of the system [6], the criticalness to play out a specific correspondence [7] (the direness is a relative term, and will change with evolving systems, if a node needs to send information to another node in a similar system, at that point the earnestness of sending information may be low, this parameter is again at the caution of the system planner), the span of the information being exchanged [8] and different parameters as suited for the systems under thought.

These diverse system and node parameters are then combined so as to make a parameter highlight vector set [9], which can be utilized for handoff decision making process. Alongside this vector set, another determination vector set is made which contains data about which parameters to choose and which ones to disregard for a specific system session. For instance, amid the day time, the parameters like connection quality may be should have been considered for ideal handoffs, while amid the evening time the connection quality is normally great, so it may be disposed of so as to perform successful handoffs [10]. These methods are called as handoff runs and are connected to every one of the parameters so as to assess scores for every one of the node to arrange mixes. The node to arrange blend which has the most elevated score is chosen as the most appropriate handoff decision, and on the off chance that the node isn't as of now in the most reasonable system, it is moved to that organize utilizing a make before break strategy, and the other system is given all the node's subtleties so as to carry on the availability further [11].

This whole procedure requires a considerable measure of calculations, which increments exponentially as the quantity of nodes increment, and in this manner this procedure requires a great deal of computational power [12]. This computational power is normally taken from the handoff decision units, which diminishes the general proficiency of the system [13]. Therefore, there is a need to offload these calculations over the cloud so as to enhance the system QoS [14], which is actually what has been done in this paper. Aside from simply offloading the basic guideline application procedure to the cloud, this paper additionally proposes a novel machine learning and AI based handoff calculation which can be utilized so as to enhance the general proficiency of the handoff decision process [15], so the system determination can result in better vitality effectiveness, low deferral, high throughput and ideal number of handoffs with ideal number of parameter prerequisite for the handoff decision process [16].

The next section describes various handoff decision techniques and their peculiarities, followed by our proposed approach towards achieving high efficiency handoffs, and concluded by the results and some interesting observations about the developed algorithm. The paper also suggests some further improvements which can be done in order to optimize the handoff decisions in the network further.

II. Related Work

In this section, With the three stages accessible for playing out a handoff in heterogeneous systems, the MT will have a decision of a few systems to which it can associate with. In any case, the result of the decision period of the VHO, which is subject to a few parameters like accessible data transfer capacity, battery control status of the portable terminal, cost, got flag quality (RSS), and so on will choose the system to which an association will be made. The execution of the system association likewise depends, to some extent, on the flag quality which additionally delineates the power present in the got flag. Between a MT and passage (AP), the remote flag quality toward every path decides the aggregate sum of system data transfer capacity accessible along that association. RSS has an incredible job in the level decision process because of its similarity between the present connection point and that of the hopeful connection focuses. Yet, in VHO, the RSSs are unique because of awry nature of the heterogeneous systems. Be that as it may, it tends to be utilized to decide the accessibility and additionally the state of various systems. On the off chance that more than one hopeful system is accessible, the MT should connect itself with the one having the most grounded RSS as it does in HHO. Significant work has been done in writing to decide the suitable parameters that can be considered in the decision procedure for VHO. In [11], the creators have proposed a vertical handoff decision (VHD) calculation that augments the general battery lifetime of the versatile terminal in a similar inclusion region and furthermore goes for similarly conveying the traffic stack over the systems. This calculation when actualized in various Vertical Handoff Decision Controllers (VHDC) situated in the entrance systems can give the VHD capacity to a locale covering one or numerous APs or BSs. The decision contributions for the VHDCs are gotten over the Media Independent Handoff Function (MIHF) of IEEE 802.21. This MIHF encourages benchmarks based message to be traded between the different access systems (or connection focuses) to share data about the present connection layer conditions, traffic stack, arrange limits, and so on. In spite of the fact that the execution results which depend on point by point reproductions demonstrate that the proposed calculations perform nearly better, the got flag quality which is a noteworthy pointer of the nature of administration, ought to be considered to set up the predominance of the calculation. It would have been a superior alternative to think about the likelihood of the quantity of superfluous handoffs occurring or the likelihood of the quantity of handoffs being missed prompting increment in the likelihood of call dropping. In[12], a decision technique called ALIVE – HO(adaptive lifetime-based vertical handoff) is proposed which depends on the Received Signal Strength (RSS).This parameter is utilized to evaluate inclusion of the remote system and the best system is chosen utilizing vertical handoff calculations. A versatile handoff dependent on the accessibility of the data transmission till the time the MT remains in the system is considered. ALIVE-HO calculation powerfully receives to the Mobile Terminals (MT)velocity to diminish the pointless number of handoffs and ping pong impact however the likelihood of handoff increments with the separation from the AP. It is likewise settled that the quantity of superfluous handoffs utilizing ALIVE handoff calculation is not as much as that of calculations dependent on customary RSS hysteresis. As per the creators, the least complex strategy to expand RSS is to build the transmit control, which needs further examination, since an expansion in transmit power may prompt an expansion in obstruction prompting a decline in QoS. This may be a pragmatic arrangement just in open regions and may not be attainable in urban zones due the jumbled condition, in which case extra parameters should be considered in the decision procedure. Stevens et. al [13] have chosen parameters, for example, data transmission, deferral, jitter and bit mistake rate (BER) to lead their correlations of a portion of the noticeable decision calculations in writing, that is, straightforward added substance weighting (SAW), strategy for request inclination by similitude to perfect arrangement (TOPSIS), multiplicative type weighting (MEW) and the dark social investigation (GRA).Good execution enhancement of SAW and GRA more than a few vertical handoff decision calculations has been acquired. The GRA decision calculation gave a marginally higher data transfer capacity and lower delay for intelligent and foundation traffic classes while MEW, SAW and TOPSIS gave relatively comparative execution. The accessible data transfer capacity and postponement experienced has been considered as decision parameters by Chuanxiong et al [10]. The execution of the calculation is assessed against throughput and pointless handoff rate that is experienced amid a handoff procedure. Interesting component of this work is the capacity of responding to meandering occasions proactively and precisely with a little handoff delay. The proposed framework responds to wandering occasions proactively and precisely, and furthermore keeps up the associations' progression flawlessly. Crafted by [14] utilizes the utilization of a cost work including data transfer capacity, control utilization and money related expense for showing the execution of the work regarding the handoff idleness experienced. All calculations that utilize cost capacities require manual contributions by the client. This could be a hindrance since the calculation needs to take into account the clients ask for as one of the information parameter and could result in poor handoff in case of any blame in the information. In the dynamic decision demonstrate proposed by Pramod and Saxena[15], dynamic variables like the RSS and speed of the portable, and static components like cost, data transmission and power utilization of the versatile terminal has been mulled over for settling on a decision to handoff. This model has been created utilizing a three stage approach to be specific the need stage, the typical stage, and the decision stage. Choosing the best system dependent on the dynamic components is performed in the need stage. A system with most elevated contrast between the RSS and the edge RSS is given need. In the typical stage, cost work for every static parameter like cost, transfer speed and power is recorded dependent on their weight factors. At that point the system with most noteworthy weight factor is chosen. In the decision stage, decision concerning which is the best system to handoff is made by acquiring a score work i.e., by duplicating the need from the primary stage with the cost work from the ordinary stage for every one of the hopeful system. The system with the most noteworthy score capacity will be the hopeful system. This model goes for joining both static and dynamic parameters to play out a handoff. Despite the fact that a decrease in the quantity of superfluous handoff has been built up this model is a basic model and is increasingly reasonable for delicate vertical handoffs. Anyway the creators need to expound on the interim over which RSS is determined and how speed of the versatile is determined. Calculations managing both even and vertical handoff situations with insignificant changes in framework which requires organization of handoff servers just on the Internet was proposed by Ling-Jyh Chen et al[4]. The Universal Seamless Handoff Architecture (USHA) is an upper layer arrangement and gives a consistent handoff as opposed to utilizing new transport convention or new session layer through the middleware plan methodology. The handoff, either vertical or flat, happens just on overlaid systems utilizing delicate handoff strategy. USHA may lose availability to upper layer application, if the inclusion from numerous entrance strategies neglects to cover.

The Received flag quality (RSS) is assessed as the primary measurement alongside other decision measurements. This structures the top notch of Vertical Handoff Decision Algorithms (VHDAs). This methodology considers the RSS of an introduced system with the RSS of the accessible target arrange. In [7] an advancement plot for performing handover utilizing client abide time to accomplish mean throughput was displayed. The strategy exhibited utilized the stay clock of the portable to upgrade handoff decision for the objective access organize. In [8] a calculation for handoff between 3G radio and WLANS get to organize was exhibited. The proposed plan joined the Received flag quality estimation either with data transmission or stay clock. The proposed calculation gives greatest throughput of the portable client.

The utilization of Cost capacities shapes the below average of VHDAs. This technique utilizes the assessment of the client decision and systems estimation as criteria for handoff. Creators in [9] exhibited an arrangement which empowered VHO crosswise over heterogeneous systems dependent on various parameters, for example, control utilization, accessible transmission capacity and administration cost. An assessment of VHD utilizing versatile cost work was introduced while vertical handoff decision calculation for heterogeneous system was assessed utilizing Markov decision process [10]. The utilization of cost work based VHDA is ordinarily known to be proficient, adaptable and has a low usage multifaceted nature.

The second rate class of VHDAs utilizes some different criteria for handoff decision execution. The different criteria VHDAs consolidate the cost work based calculation and the computational knowledge based calculation for choosing an appropriate target arrange among heterogeneous system. This methodology can be isolated into numerous trait decision making (MADM) and the various target decision making (MODM) Handoff decision in an entrance systems can be assessed utilizing (MADM) calculation, for example, weighted total model (WSM) or Multiplicative Exponent weighting (MEW), Technique for request inclination by comparability to perfect arrangement (TOPSIS), Analytic chain of importance process (AHP) and Gray Relational

Analysis (GRA). In [11], creators proposed two scientific blends of AHP and GRA systems in a calculation for choosing systems among WLAN and UMTS. The AHP was utilized to accomplish weighting of QoS parameter dependent on administration application and client exhibitions while the GRA was utilized to rank the system choices with quicker and less complex usage than AHP. In [12], an enhancement for the method in [11] was proposed utilizing QoS parameters in bundle exchanged systems while assessing utilizing genuine estimations. The proposed calculation relies upon the nature of administration prerequisites of the administration asked for by the client hardware. Numerous criteria VHD calculations are productive, adaptable and have a medium-level execution intricacy.

The fourth class of VHDAs depends on computational knowledge. This methodology makes VHD by applying any computational knowledge system, for example, Fuzzy Logic (FL), Fuzzy Multiple Attribute Decision Making (FMADM), Artificial Neural Networks (ANN), Simulating Annealing (SA) or Genetic Algorithm (GA). Creators in [13] proposed a speed versatile arrangement empowered VHDA dependent on sort 2 Fuzzy rationale to find and choose best handoff hopeful system with greatest throughput for vehicular heterogeneous system. In [14], client inclination alongside ANN was utilized to execute handoff for the best offered administration among various reachable systems. For the most part, Computational knowledge based handoff decision calculations have high execution unpredictability; in any case, they enhance client's fulfillment amid wandering and have high proficiency.

The fifth classification of VHDAs utilizes the learning of the setting mindful of data identifying with the MT and the system. This methodology thinks about client data, system and gadget to ensure high caliber of administration and to keep up availability for abnormal state client's fulfillment. Creators in [15] proposed setting mindful VHDA that figures the limit region utilizing portable terminal speed and cell size of the WLAN. Handoff is activated from WLAN to 3G at whatever point the versatile terminal enters the limit region of the WLAN. Creators in [16] proposed clog – mindful proactive vertical handoff plot that utilizes alliance amusement. This plan was appeared to oversee clog superior to anything the conventional blockage control calculation.

III. METHODOLOGY

Deep learning is a recent field of study for many areas, in this section we describe the algorithm developed by us for solving the issues of heterogenous handoffs which result in low QoS and low quality handoff decisions. Our algorithm is based on maximization of the primary QoS parameters which are throughput and minimizing the handoff delay and energy needed for performing handoffs. This is achieved by careful design of the activation functions of the deep nets, and storing the decision values into a handoff table. The algorithm performs the decisions using the following steps,

- Initialize the algorithm parameters,
  - Number of neurons (Nn)
  - Number of iterations (Ni)
  - Total handoff parameters (Pth)
  - Weight update factor (Wf)
- Initialize all neurons with zero weights
- For each iteration, and for each neuronwith weight 0, update the weight using the following process,
  - Apply gold code in order to generate a stochastic number between 2 to Pth, and call this number as Rp
  - Generate a stochastic series of length Rp, and include unique elements in this series, each element can have a maximum value of Pth, let this series be called as Sp
  - Apply game theory for performing handoff using the parameters stored in Sp, and check the handoff results
  - Once the handoff is completed, evaluate QoS parameters,
    - Total handoffs (Th)
    - Total delay (Td)
    - Total throughput (Tt)
  - Find the activation function (Af) using equation 1,

$$Af = \frac{Td + Th}{Tt + 1} \ldots Eqn\ (1)$$

- Reloop all the steps for all iterations and obtain different values for Af
- Find the activation threshold for each iteration using the following function,

$$Ath = \mathrm{Wf} * \frac{\sum Af}{Ni} \ldots (Eqn\ 2)$$

- Update weight of all neurons, and set it to 1, which satisfy the following condition given in equation 3

$$Af > Ath \ldots (Eqn\ 3)$$

- Re-iterate the above process for all iterations and write the obtained values in the following deep learning table 1,

Sp	Th	Td	Tt	Af

Table 1. Neuron status

- Evaluate table 1 and find the parameter numbers in Sp where the value of Af is minimum

- Perform handoff using these values of Sp, and repeat the entire process after a certain stochastic interval of time, movements or communications

- After the given stochastic interval, update table 1 and re-evaluate the minimum value of Af in order to select the parameters in array Sp for handoff. This will make sure that the value of Td and Th is minimized while the value of Tt is maximized for any given handoff system

The developed algorithm can take any number of parameters for performing the handoff process, and for this research we have used the following parameters to perform the handoff process,

• Signal to noise ratio

• Network bandwidth

• Received signal strength indicator

• Node's interest in the given network

• Network coverage

• Link quality

• Data rate of the node

Parameter selection is one thing, while handoff algorithm selection is another, for the purpose of this text we used a game theory based algorithm which finds out the score of each network based on the node's network parameters and performs handoff to the network where the score is maximum. This is the most effective technique of performing multi-parameter handoff in wireless systems.

The handoff algorithm makes sure that the most effective network is selected for handoff and that the network score is maximum for the selected node. The algorithm can be extended to add more parameters into the activation function, so that the handoff decision can incorporate better optimization, but in doing that the researchers must also modify the number of neurons and the number of iterations in order for better deep learning efficiency. The results of the proposed algorithm are discussed in the next section.

IV. Results and Discussion

The deep net based optimization algorithm was simulated in the NS2 environment using the MIH patch and core optimization. The following parameters were selected while simulation,

Parameter Name	Value
MAC Layer	802.16
Network Size	100x100 to 500x500
Number of nodes	20 to 100
Node mobility	Upto 100 kmph
Number of communications	10 to 100
Number of networks	2 (WiFi and WiMAX)

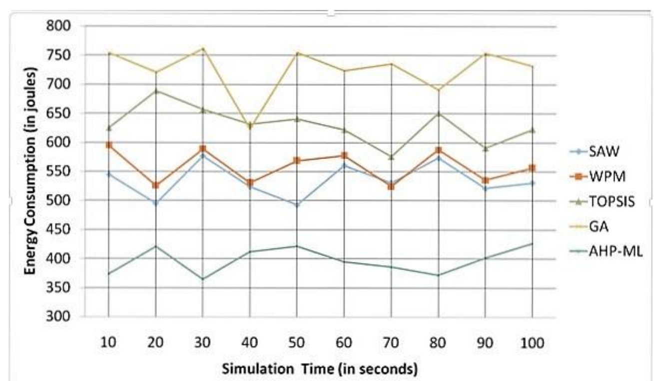

Fig.1

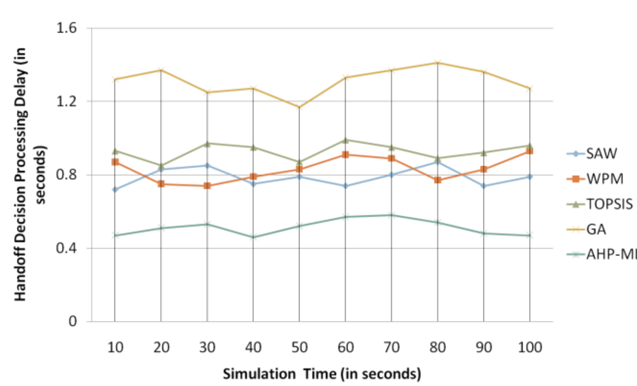

Fig.2

From these comparisons it is clear that the proposed algorithm not only reduces the handoff delay but also reduces the delay jitter, the energy consumption of the network thereby improving the lifetime of the network, by keeping the values of packet delivery ratio and throughput almost consistent.

include important findings discussed briefly. Wherever necessary, elaborate on the tables and figures without repeating their contents. Interpret the findings in view of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. However, valid colored photographs can also be published.

V. Conclusion and Future Scope

From the results it is made clear that the deep net based handoff decision optimization algorithm reduces the number of handoffs, increases the handoff throughput and reduces the delay incurred during the handover process. The algorithm can be further optimized as per the application decided by the researcher and is flexible enough to incorporate any number of handoff parameters and also can be used for optimization of any QoS related handoff parameter

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