Neural embedded smart link generation scheme for heterogeneous network

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Abstract

The Long Term Evolution (LTE) network is a very much popular network in heterogeneous network. Heterogeneous networks provide maximum data rate by integrating various technologies and channels, based on appropriate network selection. For the sensible data transmission in the LTE network, noise plays an vital role as channel is a free space. The minimum noise channel selection is a decision of present and previous status of network channel. Proposed scheme develop neural network model, which will act as a smart link generation scheme for computing minimum noise channel path for sensible data transmission. Hence, proposed scheme will improve performance of the network. Result indicates that, proposed scheme improves throughput and system reliability. Proposed scheme is also reduces packet loss rate and energy consumption in contrast with conventional techniques.

Keywords: Computer science

1. Introduction

LTE network or future generation network are typically based on integration of GSM and UMTS system, which will form the heterogeneous system. Basic LTE architecture is shown in Fig. 1.

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Long Term Evolution (LTE) network is a hybrid system, where a special type of node called eNB (evolved node base station) is deployed at the local network. LTE network can support any underneath radio networks, like Wi-Fi/Bluetooth, MANET etc., and integrate these networks for accessing internetwork. Basically LTE is a data packet network, where voice data is also packet data (prime example being Reliance Jio). The LTE network can provide maximum data rate of 300Mbps for downloading and 75 Mbps data rate for uploading transmission, where user equipment decides the data rate. The LTE network uses OFDMA modulation for down-link and SC-FDMA for up-link transmission. In LTE network, eNB node plays an important role for monitoring and transmission of data packets. Every eNB is responsible for data rate change, signal power and modulation index to every user nodes. Hence eNB nodes are responsible for resource allocation like bandwidth and power to local nodes. The job of eNB is to allocate minimum noise data path, which is more complex. This allocation is proposed and implemented in our work.

Neural networks are mainly used to predict the mobility of nodes in the wireless networks. It also used to reduce the complexity in real time applications.

2. Related work

In this article [1] a novel scheme is designed and developed for smart link management, which continuously monitor the link to choose minimum interference path to forward the incoming data packets. In this paper [2] the different types of applications have been presented based on the feed forward neural network. This article [3] explains about the different models for selecting shortest route as well as computing energy for that route. In these papers [4, 5] described about how broadband is given to a mobile communication network and device to device communication will increase the LTE utilization [4, 5]. This [6] article discuss about resource assignment scheme based on the two important parameters interference and Qos of the network. This paper [7] discusses about coordinated and distributed types of resource scheme. Here also explained about self-organized and frequency reuse concepts. The authors of
the paper [8] represent about varying traffic load related to real time application, which utilizes optimization to achieve system allocation. The aim of this paper [9] will explained about resource allocation in lte system, based on utility fairness method. The author of the paper [10] reported on resource allocation and joint-user approaches are used to improve the throughput of the system. This article [11] illustrates that, time and frequency factors can also be used to allocate resources in the system. However the adaptive power utilizing schemes are used to increase the efficiency. This paper [12] focus on elastic and inelastic based user distribution methods. Based on utility-function, each equipment is allocated. For carrier assignment to user an aggregation distribution method is used. This article [13] will proposed the error free distribution scheme for allocation, which also uses optimization scheme. These articles [14, 15] represent about how coverage and capacity is improved using relay information. It discuss about resource scheme using adaptive techniques. Here, it also uses the concept of subgroup and diversity. This paper [16] describe about resource assignment based on optimization using carrier aggregation. This is also used for LTE and MIMO systems. These articles [17, 18] gives about the Qos enhancement using integration of optimization algorithms. Virtual token method and exp-rule methods are discussed. This will lead to high performance system in terms of throughput. This paper tells about LTE network estimation using HMM for various performance computation. This paper [19] will propose optimal resource allocation based on reverse iterative method. Investigation of self-organization is proposed for allocation of resource based on resource block availability. This method explained in [20] is also used to reduce interference related to co-channel. This article [21] gives about, how frequency reuse methods are improving LTE system capacity. This also explains how capacity is expanded using optimal schemes. These papers [22, 23] represent how OFDMA will improve LTE system performance. This also explains, how frequency and overtime is scheduled, based on availability of resource blocks. Important factors related to allocations are RB scheduling, optimization of power and client association. The article [24] explains about fuzzy based resource distribution scheme for LTE-A system is proposed for multimedia traffic. This is simulated for high traffic load. In this [25] paper, advance management for resource allocation for LTE system is proposed using Shannon limit. This paper is also described about packet scheduling for downlink transmission.

Since, noise will play crucial role in data transmission path. However, the issued exists in present existing system. The existing system finds the problems in computing minimum noise channel path because of fixed data path for every round of transmission. This will increase the data loss and packet drop. Hence, the proposed work will compute minimum noise channel path for every round of data transmission using neural embedded smart link scheme.

The organization of this paper is as follows. Section 3 explains methodology for neural embedded smart link scheme, with neural network structure and different algorithms
for energy and delay computation in the data path. Section 4 explains simulation and results of the proposed work. Finally, we present conclusion in Section 5.

3. Methodology

3.1. Block diagram

Proposed neural embedded smart link generation scheme is shown in Fig. 2. This work is specially designed to compute smart link by means of minimum noise shortest channel path. Every time, scheme computes the link with minimum noise for better SNR to achieve efficient data transmission.

Fig. 2 illustrate about neural embedded smart link scheme. The scheme diagram consists of four important parts which are explained below,

Choosing route block: This is the first block of the proposed scheme. Whenever any mobile node trying to transmit the data packet to the destination node, initially it setup the path between source node and sink node with shortest path between them. After path setup, source node will initiate data transmission to the destination. When it completes the first round of data transmission, for next round of data transmission, it checks the path noise using the smart link computation unit.

Smart Link Computation: Its job is to generate minimum noise shortest path. The source to destination path is also depends on distance and residual energy in the path. If the previous data path comprises of minimum noise, then it continue with the same path, otherwise it computes the new shortest path with minimum noise by means of neural network computation unit.

Neural network computation: This block is intelligent and significant of proposed scheme. This block will compute the minimum noise shortest path by utilizing energy consumed and delay parameter of previous path data transmission. This is done by

![Neural Embedded Smart Link Scheme](image)

**Fig. 2.** Neural embedded smart link scheme.
using Route Back Propagation (RBP). RBP will provide the feedback regarding previous data path energy consumption and delay. Based on energy and delay value provided by RBP, neural network will compute the shortest path with less noise. These energy and delay related values calculated by RBP is also utilized by output activation function. The activation function is classified into four different values as Low, Medium, High and Very High, based on noise present in the data transmission path.

**Best route computation:** This is the decision block of the scheme. Output value computed by the activation function of the neural network based on noise in the path. After computation, the model will retain the same previous path or switch to another minimum noise channel path for data transmission.

The proposed neural network structure is as shown in Fig. 3. Once the path is established, it initiates data transmission and energy consumed value and delay are noted down. Based on energy consumption and delay of the previous data transmission, it will express value in-terms of noise level. If noise is low then it retain same path otherwise it switch to another minimum noise shortest path for next round of data transmission.

Since energy consumed and delay in data path are inputs to neural network model, so we are developing the algorithms to calculate value of energy consumption and delay in the data path. Based on these inputs, proposed scheme model generates output values. Then output values will compare with the threshold value, based on comparison, it will represent output as Low, Medium, High and Very High.

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**Algorithm for delay calculation:**

1. Initialize total number of nodes: \( N = \{n_1, n_2, \ldots, n_m\} \)
2. Choose a shortest path between source to destination.
   - Choose ‘k’ variable where \( E_i^D \) is minimum as
   - \( E_i^D \) is the energy w.r.t packet delivery ratio of source node.
   - \( k = \arg \min \{E_i^D\} \)
3. Also \( Q_i^D \) as smallest Euclidian distance from source to destination.
   - \( Q_i^D = k \sum_{i=1}^{m} |n_i - n_D| \)
   - where \( n_i \) and \( n_D \) are source and destination nodes
4. Calculate \( V_j(\text{old}) = Q_i^D \)
   - \( V_j \) intermediate weight vector
   - Update \( V_j(\text{new}) = V_j(\text{old}) + \mu(n_i-v_j(\text{old})) \) Where \( \mu \) learning rate
5. Calculate delay using linear function with distance.
   - Then minimum value of \( E_i^D \) is shortest path with minimum delay.
In our proposed scheme, neural network is trained with input parameters. After computing both energy and delay of previous data transmission path, it compares with threshold value. The output is expressed in-terms of four different classes as LOW, MEDIUM, HIGH and VERY HIGH. After computing output of the activation function, the path is retained or switched to another based on presence of channel noise.

**Algorithm for Energy consumption in the route:**

1. Total number of path in network- r₁, r₂, ……, rₘ w.r.t Eᵢ^D
2. j = 1, initialize the counter for available path.
3. For every path from source to destination
4. Energy consumption for path
   
   **Repeat**
   
   \[ Ec, m = \sum_{i=1}^{m} mi E_{\text{max}} L \]
   
   where \( Ec = \) Energy consumption
   
   \( E_{\text{max}} = \) Maximum energy
   
   \( m = \) Number of paths
   
   \( L = \) packet length (no of bits)
   
6. Update the energy values for different paths as \( Ec, m \) updated
   
   **Until** \( |Ec, m \text{updated} | < q_1 \) (predefined threshold)
7. \( j = j+1 \) (for next path energy calculation),
8. go to step 3

Compare all path for energy consumptions and select smallest energy consumption path for data transmission.

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![Fig. 3. Structure of Neural Network for SLM scheme.](https://doi.org/10.1016/j.heliyon.2018.e01089)
4. Results

4.1. Simulations

Performance of neural embedded scheme is measured in-terms of throughput computed and verified using mat-lab simulation. The result shows the outcomes of neural network based smart link generation. The simulation model of network topology is as shown in Fig. 4. For simulation, we consider the 30 total nodes, with 4 source nodes and a sink node. All source nodes are sending message of length 100. The SNR for the data path is -20, these data message are going to transmit for 10 rounds from each source node to sink node.

Fig. 4 represents generation of network architecture. In this simulation, we consider 30 total numbers of nodes. Among these, some nodes are source nodes, which transmit data packet to destination based on route establishment, which is having minimum noise shortest path.

In the present existing system, once the path is established between source and destination for data transmission, it is fixed for every round of data transmission, even

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**Algorithm for Link output computation:**

The output of the neural embedded smart link management is computed as based noise level in the channel path.

\[
Y_k = \alpha (\text{noise})
\]

- Low: \(0 < \alpha (\text{noise}) < 1\)
- Medium: \(1 < \alpha (\text{noise}) < 5\)
- High: \(5 < \alpha (\text{noise}) < 10\)
- Very high: \(10 < \alpha (\text{noise})\)

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Fig. 4. Architecture of network.
though path is having more noise or some times failure of intermediate nodes. Therefore this will create more packet loss and hence reduction in efficiency.

To overcome problem of present system, we developed a novel scheme which is shown in Fig. 5. In the proposed scheme, once path is established between source and destination, it can not be fixed for next round of transmission. After every round of data transmission, it computes the noise value in data path based on energy consumption and delay of data path. If this noise value is low or tolerable value as compared to threshold value, then it continue with same data path otherwise it compute next minimum noise shortest path for data transmission. Since scheme is not only depends on only one path, therefore it reduces packet loss and increase efficiency.

4.2. Simulation results

The result explains about the outcomes of proposed work. Results are compares with present existing system parameters. The work is simulated on i3 laptop using mat-

lab-16. The performance parameters are considered for proposed work is as follows.

- **System efficiency**: System efficiency is computed as the ratio of successful received data packets with total transmitted data packets by the number of mobile nodes. Efficiency can be measured in-terms of throughput.

- **System reliability**: It is described as the ratio of total number of reliable links with that of total links, with respect to number of mobile nodes. Reliability is expressed in BER of the network.

![Fig. 5. Data packet transmission in proposed system.](https://doi.org/10.1016/j.heliyon.2018.e01089)
- **Packet Loss rate:** It is difference between the total transmitted data packets to the received data packets with respect to every refresher time.

- **Energy consumption:** It is a percentage measure of energy consumption in the network. In proposed work, data path consumes less energy comparing with present existing system, because proposed scheme data path always choose minimum noise shortest path.

Table 1 gives results of present existing system execution. From the Table 1 it is observed that, as noise in the path decreases, average energy consumption and bit error rate (BER) are also going to decreases.

Table 2 gives results of proposed system scheme execution. From the Table 2 it is viewed that, as noise in the path decreases, consumption of energy and bit error rate (BER) are also going to decreases. Hence there is increase in throughput. So from the results, we present that our proposed scheme will improve throughput, reliability in-terms of BER and reduces energy consumption.

Fig. 6 shows how efficiency is improved by deploying our proposed scheme in the network. Since proposed scheme improves the efficiency, in-tern it reduces packet loss. It also represents how efficiency is retained by comparing with present existing system, even at the maximum channel noise path of -50 SNR. From the diagram it is

### Table 1. Results of present existing system.

| Number of nodes | Message length (packets) | SNR (dB) | Round | Existing system |
|-----------------|--------------------------|----------|-------|-----------------|
|                 |                          |          |       | Average energy consumption | Throughput (%) | BER (Reliability) |
| 30              | 100                      | -50      | 10    | 30000           | 1              | 48 |
| 30              | 100                      | -40      | 10    | 3360            | 3              | 39 |
| 30              | 100                      | -30      | 10    | 474             | 6              | 29 |
| 30              | 100                      | -20      | 10    | 85              | 10             | 6  |
| 30              | 100                      | -10      | 10    | 29              | 20             | 0.5 |

### Table 2. Results of proposed neural embedded system.

| Number of nodes | Message length (packets) | SNR (dB) | Round | Proposed system |
|-----------------|--------------------------|----------|-------|-----------------|
|                 |                          |          |       | Average energy consumption | Throughput (%) | BER (Reliability) |
| 30              | 100                      | -50      | 10    | 17655           | 30             | 25 |
| 30              | 100                      | -40      | 10    | 1690            | 40             | 20 |
| 30              | 100                      | -30      | 10    | 260             | 50             | 15 |
| 30              | 100                      | -20      | 10    | 70              | 60             | 5  |
| 30              | 100                      | -10      | 10    | 25              | 70             | 0  |
observed that, there are more values of throughput for proposed scheme, because proposed scheme always select minimum noise shortest path.

The Fig. 7 shows graph of system reliability. Since it is percentage measure of BER in the network. In the proposed work, the BER is very less, because the neural network model selects minimum noise shortest path. For every round of data transmission. Hence proposed scheme reliability is more as compared with present existing system.

Fig. 8 illustrates about graph of packet loss rate v/s number of mobile nodes. In the proposed scheme, data path is not fixed because, neural network model always
computes low noise with shortest path for every round of data transmission from source to destination node. Hence the packet loss rate is very very low as compared to present existing system.

Fig. 9 represent the energy consumption analysis. In our proposed work, data path is going to change based on the noise level. Since energy is totally depends on number of iterations by network. Therefore proposed scheme consumes less energy with respect to number of iterations for data packet in the network. Hence energy consumption in proposed work is very less compared to present existing system.
5. Conclusions

Since, channel noise plays a very important role for data transmission in heterogeneous network, which will affect the performance parameters of the network. The proposed work has been highlighting on increase in reliability by controlling bit error rate and reducing packet loss by energy management. The scheme has been compared with single SNR parameter with our multi-parameter such as delay energy and noise, which shows substantial increase in the throughput. So our scheme aimed to achieve better results with neural network simulation.

Declarations

Author contribution statement

Satyanarayan K. Padaganur: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Jayashree D. Mallapur: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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