Teaching Learning Based Optimization Algorithm for FiWi Network

Uma Rathore Bhatt¹, Nitin Chouhan², Chanchal Agrawal³, Raksha Upadhyay⁴

¹,²,³,⁴Department of Electronics & Telecommunication, Institute of Engineering & Technology, Devi Ahilya University, Indore, INDIA

ABSTRACT

Nowadays, there is a huge requirement of bandwidth and mobility to end users. For fulfilling this, Fiber-Wireless (Fi-Wi) networks are designed consolidating the advantages of both optical and wireless networks. Optical networks provide high bandwidth and stability while wireless networks provide cost efficiency and mobility. An efficient optimization method called ‘Teaching–Learning-Based Optimization (TLBO)’ is analyzed in this paper for placement of ONUs in FiWi networks and optimization for finding the global solutions. The analyzed method is based on the effect of the influence of a teacher on the output of learners in a class. The basic philosophy of the method is explained in detail. The effectiveness of the method as compared to the other optimization methods is also explained.

Keywords— Fiber Wireless (FiWi), ONU/placement, TLBO.

I. INTRODUCTION

Fi-Wi network is a combination of Passive Optical Network (PON) and Wireless Access Networks. PON provides excellent bandwidth capacity and stability, but fails to provide flexibility and mobility to users. On the other hand, wireless access networks provide flexibility and cost efficiency, but limited in providing bandwidth to end users. Hence, the integration of both the technologies converge their advantages and thus generate a reliable, robust and high capacity Fi-Wi network[1-5].

Figure 1 describes Fi-Wi network architecture in which feeder fiber is deployed from OLT to RN and after that distribution fiber is deployed between RN and ONUs and each of the ONU, wirelessly connected with the wireless routers of wireless domain. In Fi-Wi network end users can communicate with Wireless Routers (WR) and the WR communicates with ONU wirelessly and after that ONU will communicate with the OLT using optical fiber link deployed between them. Fi-Wi access network support various types of communication i.e., upstream, downstream and peer-to-peer communication.

One of the important issue in FiWi Network is the placement of ONUs in an optimal manner. Various researchers proposed different optimization algorithm for ONU Placement so far. TLBO is one of them which were not applied in FiWi to the best of our knowledge. Therefore, in this paper we discussed TLBO algorithm and implementation of it in FiWi network.
The rest of the paper is organized as: Section 2 consist of Literature survey. TLBO algorithm is discussed in Section 3. Finally we conclude paper in Section 4.

II. LITERATURE SURVEY

The performance of network largely depends upon the placement of ONUs since, ONUs are the interlinks between wireless and optical ends. Various algorithms are proposed for deployment of ONUs in the FiWi networks namely random approach, deterministic approach, greedy approach, Simulated Annealing, Mixed Integer Programming, Primal model, Tabu search, Load Balanced Optical Network Unit, genetic approach and Hybrid algorithm.

Random and deterministic approach allows placement of ONUs by dividing the network into multiple non overlapping regions. In random approach ONUs are deployed in the random manner. It is the simplest method but does not provide cost effective solution and the ONUs may bunch up in some parts of network. In deterministic approach, ONUs are placed in centre of each region and hence, this method works well for symmetric networks but is not suitable for non linear networks [6].

In greedy approach, first the ONUs are placed deterministically then the distances of all ONUs from each user is found and for each user an ordered set is formed which contain distances from all ONUs as set elements. Then, primary ONU with minimum distance from the user is identified. This method provides good solution for uniform distribution. It performs local optimization of ONU but fails to provide globally optimum solution. For this another approach named simulated annealing is proposed. Its consists of 5 phases, (i) initialization phase – ONUs are placed in greedy manner initially,(ii) perturbation phase- ONUs are relocated with small random amount,(iii) cost-calculation phase- the algorithm calculates the new cost of ONU placement,(iv) acceptance phase- It accepts the relocation of ONU if the new cost of deployment is lower.(v) update phase- Otherwise, its accepts the relocation with certain probability and repeat it until there is no further cost improvement. It provides improved solution over greedy but may not converge for discontinuous cost model [7].

Mixed Integer Programming (MIP) considers the optimum placement of BSs and ONUs at front end and the fiber layout at back end .In this optimization scheme cost is minimized by minimizing the number of BSs and ONUs and planning an efficient fiber layout. MIP model consider several constraints and take high processing time to provide optimal solution [8].

S. Sarkar proposed another cost efficient model called Primal model for placement of ONUs and BSs. For that several constraints are to be satisfied – BS and ONU installation constraint, their capacity constraint, user assignment constraint, channel assignment constraint, and channel interference constraint. The Lagrangean model is used to solve the above problem [6]. The above approaches considered internet traffic only.

For both type of traffics, Zeyu Zheng proposed an algorithm known as Tabu Search algorithm. It maximizes the network throughput considering peer to peer communications by minimizing the maximum number of hops from routers to ONUs. This work does not minimize the number of ONUs [9].

Yejun Liu proposed Load balanced ONU placement (LBOP) algorithm for minimizing the number of ONUs in the given network. For this he first placed the ONUs in greedy manner under the constraint of wireless hop number and then implemented the load transferring among different ONUs [10].

Then hybrid algorithm was proposed in [4], which works in two stages- in the first stage the number of ONUs is reduced so that all the wireless routers are connected to the primary ONU and in the second stage, all the remaining ONUs are moved into their own grid by genetic algorithm to find the best position. Hence, the numbers of ONUs are minimized.

All the above algorithms require different parameters for their proper working. Proper selection of the parameters is essential for the searching of the optimum solution by these algorithms. A change in the algorithm parameters changes the effectiveness of the algorithm. Hence, TLBO is analyzed for ONU Placement.

III. ANALYZED WORK

An efficient optimization method called ‘Teaching Learning Based Optimization (TLBO)’ [11] is proposed in this project for large scale non-linear optimization problems for finding the global solutions. The proposed method is based on the effect of the influence of a teacher on the output of learners in a class.

Some of the well known meta-heuristics developed during the last three decades are: Genetic Algorithm (GA) [12] which works on the principle of the Darwinian theory of the survival of the fittest and the theory of evolution of the living beings; Ant Colony Optimization (ACO) [6] which works on the foraging behavior of the ant for the food; Particle Swarm Optimization (PSO) [16] which works on the foraging behavior of the swarm of birds; These algorithms have been applied to many engineering optimization problems and proved effective to solve some specific kind of problems.

All the above mentioned algorithms are nature-inspired population based optimization methods, but they have some limitations in one or the other aspect. The main limitation of all the algorithms mentioned above is that different parameters are required for proper working of these algorithms. Proper selection of the parameters is essential for the searching of the optimum solution by
these algorithms. A change in the algorithm parameters changes the effectiveness of the algorithm. Therefore, the efforts must be continued to develop an optimization technique which is free from the algorithm parameters, i.e. no algorithm parameters is required for the working of the algorithm. An optimization method, Teaching Learning Based Optimization (TLBO), is analyzed in this paper to obtain global solutions for continuous non-linear functions with less computational effort and high consistency. The TLBO method works on the philosophy of teaching and learning. The TLBO method is based on the effect of the influence of a teacher on the output of learners in a class. Here, output is considered in terms of results or grades. The teacher is generally considered as a highly learned person who shares his or her knowledge with the learners. The quality of a teacher affects the outcome of learners. It is obvious that a good teacher trains learners such that they can have better results in terms of their marks or grades. Moreover, learners also learn from interaction between themselves, which also helps in their results.

IV. IMPLEMENTATION of TLBO IN FiWi NETWORKS

For placement of ONUs in FiWi network using TLBO following steps are taken:

1. Firstly, a network is divided into G×G grid.
2. ONUs are placed in center region of each grid.
3. Now we form the set of wireless routers for each ONU in the network.
4. ONU which has maximum number of routers connected is considered as a teacher and all the remaining ONUs are considered as learners.
5. Now we compare the routers of teacher and each learner.
6. If there is any uncommon router between teacher and learner, then the learner will be the next teacher.
7. Now we compare routers of each learner with teachers.
8. At the end we have following teachers in the network which is the required ONUs in the network.
9. In this way we efficiently place minimum ONUs using TLBO in FiWi network.

V. CONCLUSION

FiWi provides accessibility to many end users with higher bandwidth and lower cost. One of the important key issue in FiWi Network is ONU Placement since it depends on network cost. Many researchers proposed several optimization algorithms for ONU placement which are discussed in this literature. In this paper we analyzed one of the optimization algorithm i.e. TLBO. We also present an idea to implement TLBO for ONU Placement in FiWi Network.

REFERENCES