ENERGY EFFICIENT MECHANISM FOR FIWI NETWORK

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Abstract: FiWi network provides internet services to user with higher bandwidth, better flexibility at lower cost. As number of internet users increasing day by day, Energy saving is one of the important issue in FiWi network. In this paper, we propose an energy saving algorithm for FiWi network. This scheme works in two phases viz. Head ONU selection and energy saving phase. In first phase we select the Head ONUs in the network using Particle Swarm Optimization (PSO) algorithm. In second phase we put ONUs in sleep and awaken mode according to traffic load in the network. Therefore proposed algorithm is excellent for saving energy in FiWi network.
Keywords: Fiber Wireless (FiWi); Energy Saving; Head ONU; Particle Swarm Optimization (PSO)

I. INTRODUCTION

In past year there is a rapid growth in the field of broadband access technologies which basically required higher bandwidth, better flexibility and lower cost access network. Passive Optical Network (PON) provides higher bandwidth to the users but its costly due to usage of optical devices. Wireless Mesh Network (WMN) provides services at lower cost but its limited bandwidth limit its uses. So, on integrating the technical merits of both the technologies a Fiber Wireless (FiWi) broadband access network [1]-[4] was proposed to enable user to access internet at lower cost and higher bandwidth and also providing better speed.

FiWi is a combination of PON at back-end and WMN network at front-end shown in Fig. 1. Basically PON has tree topology, in which Optical Line Terminal (OLT) in Central Office (CO) connected with multiple Optical Network Units (ONUs) via Remote Node, feeder fiber and distribution fiber. WMN has mesh topologies in which variety of users are connected through wireless routers. The data through users are first going to nearby wireless router, where router sends to its primary ONUs. ONU send this data to OLT via RN and fibers. OLT injected this data in internet backbone.

ONU Placement, Survivability and Energy Saving [6-9] are the key issues in FiWi network. Energy saving issue is most important not only in FiWi network but also in all type of networks. In FiWi network more ONUs requires more energy in the network. Therefore, there is need to design such type of network which makes minimum number of ONUs in awaken mode.

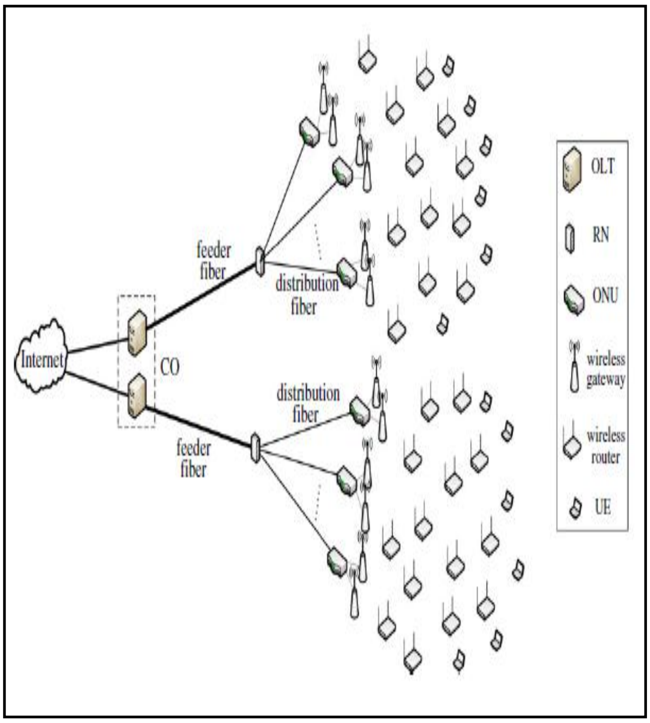

Fig. 1 Architecture of FiWi access network [5]

In this paper, an energy saving algorithm is proposed for FiWi network which works in two phases. In first phase i.e. Head ONU selection, initially we put ONUs in center region of each grid. Then find the best position of all ONUs in its grid where maximum number of router connects using PSO algorithm. Now we select Head ONUs in the network from all the ONUs on the basis of maximum routers connected to it. In second phase i.e. Energy saving phase, first put all Head ONUs in awaken mode and rest ONUs in sleep mode. Based on the traffic load increases in the network, Head ONU put one of the sleep ONU into awaken mode. As soon as traffic decreases in the network, awaken ONU again sent to sleep mode by Head ONUs. In this way proposed scheme saves energy in the network.

II. PROPOSED WORK

This section proposes an energy saving algorithm for FiWi network. If network has less traffic then few ONUs put into sleep mode to save energy. Hence we propose an algorithm which put minimum ONUs into awaken and rest are in sleep mode. According to traffic increases in the network rest ONUs put into awaken mode or sleep mode. Proposed algorithm works in two phases viz. Head ONU Selection & Energy Saving.

A. Head ONUs selection

In this phase, initially we put ONUs in center region of each grid. Then find the best position of all ONUs in its grid where maximum number of router connects using PSO algorithm. Now we select Head ONUs in the network from all the ONUs on the basis of maximum routers connected to it. Particle Swarm Optimization (PSO) is an evolutionary optimization technique based on social behavior of bird flocking or fish schooling [10]. In this, particles move around in multidimensional search space. Each particle has the ability to move with adaptable velocity in the search space. The movement of individual particle is done on the basis of there previous best position and global best position. This procedure is repeated till the optimum results are found. The main purpose of PSO is to find the best positions of ONUs in the network. It provides that position of ONUs where more number of wireless routers can communicate. First we placed ONUs in center region of each grid. Then form the set of wireless routers for each ONUs via predefined hops. Now we find the best position of all the ONUs in its grid where maximum routers connected using PSO algorithm. Arrange this ONUs in descending order, in a table according to number of routers connected. ONUs which has maximum router connected will be the first Head ONU of the network.

Compare the set of wireless router of Head ONU to that of the next ONU of the table. If there are any uncommon wireless routers then next ONU is another Head ONU of the network. Now we combine the routers of Head ONUs and compare with the next ONU of the table and repeat for all ONUs. In this way after the first phase we have Head ONUs in the network.

B. Energy Saving phase

In this phase, Head ONUs put other ONUs in awaken mode and sleep mode according to traffic load in the network. Every Head ONU has its capacity to handle the traffic. If traffic increases beyond its capacity, Head ONU put other ONU into awaken mode. As soon as traffic decreases in the network, awaken ONU again sent to sleep mode by Head ONUs. A wireless router may be connected to multiple ONUs. Hence the Head ONU maintains the information that how many ONUs are connected to a particular wireless router. First we put Head ONUs into awaken mode and rest are in sleep mode. Each Head ONU has its capacity to handle traffic and each wireless router generates random traffic therefore load on each Head ONU is different. When the traffic of particular Head ONU increases beyond its capacity, first Head ONU identifies that wireless routers which generating overhead traffic. ONU nearest to this wireless router will be awakening by Head ONU to handle the overhead traffic. If particular ONU is unable to handle overhead traffic, the next ONU will be awakening by Head ONU. As soon as overhead traffic becomes zero, the Head ONU will bring these ONUs again into sleep mode. In this way we save the energy in FiWi network and makes energy efficient FiWi network.

III. SIMULATION SETTING & RESULT

First we construct FiWi network into a 100×100 area. This area is further divided into 5×5 grid size. 40 wireless routers are randomly deployed in the network. ONUs are placed in center region of each grid shown in Fig. 2.

A. Results for Head ONU Selection Phase

In this phase first we find the best position of all the network in its grid using PSO algorithm. Now we form the set of subordinate wireless routers for each ONU according to Eq. 1. The set of wireless routers for 25 ONUs is shown in Table 1. Now according to number of wireless routers, ONUs are arrange in descending order. The arrangement of ONUs are as follows:

$ONU_9 \rightarrow ONU_8 \rightarrow ONU_{17} \rightarrow ONU_4 \rightarrow ONU_{14} \rightarrow ONU_{18} \rightarrow ONU_{19} \rightarrow ONU_{20} \rightarrow ONU_3 \rightarrow ONU_6 \rightarrow ONU_{10} \rightarrow ONU_{23} \rightarrow ONU_7 \rightarrow ONU_{11} \rightarrow ONU_{13} \rightarrow ONU_{16} \rightarrow ONU_{22} \rightarrow ONU_5 \rightarrow ONU_{12} \rightarrow ONU_{15} \rightarrow ONU_{21} \rightarrow ONU_{24} \rightarrow ONU_{25} \rightarrow ONU_2 \rightarrow ONU_1$

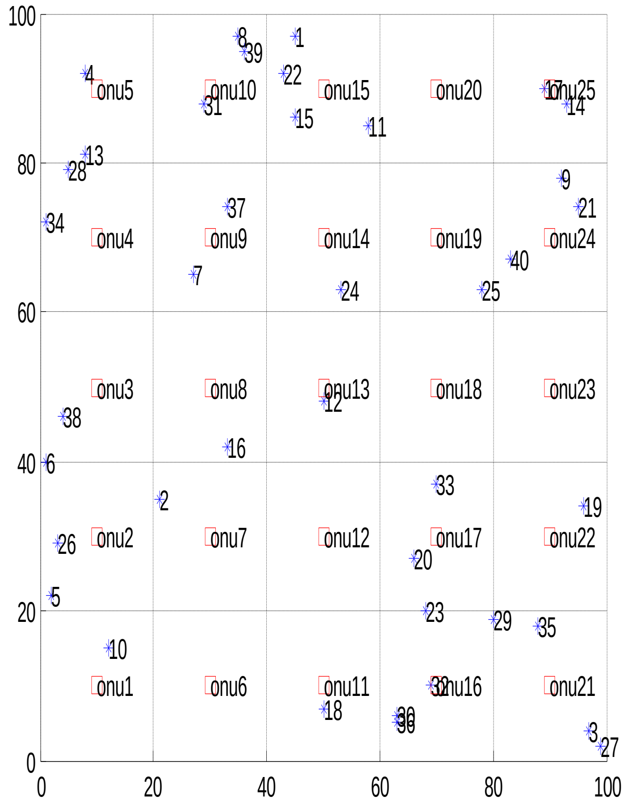

Fig. 2. Initial placement of FiWi network

ONU_9 is the first entry in the series, this ONU is the first Head ONU of the network. Now we compare the router of this ONU to the next entry i.e. routers of ONU_8. If there is any uncommon router ONU_8 will be the next Head ONU of the network. Same procedure is apply to all the ONUs and after the last ONU we have Head ONU in the network. From 25 ONUs, Head ONUs of the network are ONU_8, ONU_9, ONU_{17}, ONU_{18}, ONU_{19} and ONU_{21}.

Table 1. Set of Wireless routers for each ONU

S.No.	ONU Number	Number of wireless routers
1	ONU_1	$WR_2,WR_5,WR_6,WR_{10},WR_{16},WR_{18},WR_{26},WR_{38}$
2	ONU_2	$WR_2,WR_5,WR_6,WR_7,WR_{10},WR_{16},WR_{26},WR_{34},WR_{38}$
3	ONU_3	$WR_2,WR_5,WR_6,WR_7,WR_{10},WR_{12},WR_{13},WR_{16},WR_{26},WR_{28},WR_{31},WR_{34},WR_{37},WR_{38}$
4	ONU_4	$WR_2,WR_4,WR_6,WR_7,WR_{8,}WR_{13},WR_{15},WR_{16},WR_{22},WR_{28},WR_{31},WR_{34},WR_{37},WR_{38},WR_{39}$
5	ONU_5	$WR_1,WR_4,WR_7,WR_8,WR_{13},WR_{15},WR_{22},WR_{28},WR_{31},WR_{34},WR_{37},WR_{39}$
6	ONU_6	$WR_2,WR_5,WR_6,WR_{10},WR_{12},WR_{16},WR_{18},WR_{20},WR_{23},WR_{26},WR_{30},WR_{32},WR_{38},WR_{36}$
7	ONU_7	$WR_2,WR_5,WR_6,WR_7,WR_{10},WR_{12},WR_{16},WR_{18},WR_{20},WR_{23},WR_{24},WR_{26},WR_{38}$
8	ONU_8	$WR_2,WR_5,WR_6,WR_7,WR_{10},WR_{12},WR_{13},WR_{15},WR_{16},WR_{24},WR_{26},WR_{28},WR_{31},WR_{34},$ WR_{37},W_{38}
9	ONU_9	$WR_1,WR_2,WR_4,WR_7,WR_8,WR_{11},WR_{12},WR_{13},WR_{15},WR_{16},WR_{22},WR_{24},WR_{28},WR_{31},WR_{34},$ WR_{37}, WR_{38},W_{39}
10	ONU_{10}	$WR_1,WR_4,WR_7,WR_8,WR_{11},WR_{13},WR_{15},WR_{22},WR_{24},WR_{28},WR_{31},WR_{34},WR_{37},WR_{39}$
11	ONU_{11}	$WR_2,WR_{10},WR_{12},WR_{16},WR_{18},WR_{20},WR_{23},WR_{29},WR_{30},WR_{32},WR_{33},WR_{35},WR_{36}$
12	ONU_{12}	$WR_2,WR_{12},WR_{16},WR_{18},WR_{20},WR_{23},WR_{24},WR_{29},WR_{30},WR_{32},WR_{33},WR_{35}$
13	ONU_{13}	$WR_2,WR_7,WR_{11},WR_{12},WR_{15},WR_{16},WR_{20},WR_{23},WR_{24},WR_{25},WR_{33},WR_{37},WR_{40}$
14	ONU_{14}	$WR_1,WR_7,WR_8,WR_{11},WR_{12},WR_{15},WR_{16},WR_{22},WR_{24},WR_{25},WR_{31},WR_{33},WR_{37},WR_{39}, WR_{40}$
15	ONU_{15}	$WR_1,WR_7,WR_8,WR_{11},WR_{15},WR_{17},WR_{22},WR_{24},WR_{25},WR_{31},WR_{37},WR_{39}$
16	ONU_{16}	$WR_3,WR_{12},WR_{18},WR_{19},WR_{20},WR_{23},WR_{27},WR_{29},WR_{30},WR_{32},WR_{33},WR_{35},WR_{36}$
17	ONU_{17}	$WR_3,WR_{12},WR_{16},WR_{18},WR_{19},WR_{20},WR_{23},WR_{24},WR_{25},WR_{29},WR_{30},WR_{32},WR_{33},WR_{35},$ WR_{36},WR_{40}
18	ONU_{18}	$WR_9,WR_{11},WR_{12},WR_{15},WR_{16},WR_{19},WR_{20},WR_{21},WR_{23},WR_{24},WR_{25},$ $WR_{29},WR_{33},WR_{35},WR_{40}$
19	ONU_{19}	$WR_1,WR_7,WR_9,WR_{11},WR_{12},WR_{14},WR_{15},WR_{17},WR_{21},WR_{22},WR_{24},WR_{25},WR_{39},WR_{40}$
20	ONU_{20}	$WR_1,WR_8,WR_9,WR_{11},WR_{14},WR_{15},WR_{17},WR_{21},WR_{22},WR_{24},WR_{25},WR_{31},WR_{37}, WR_{39},WR_{40}$
21	ONU_{21}	$WR_3,WR_{18},WR_{19},WR_{20},WR_{23},WR_{27},WR_{29},WR_{30},WR_{32},WR_{33},WR_{35},WR_{36}$
22	ONU_{22}	$WR_3,WR_{19},WR_{20},WR_{23},WR_{25},WR_{27},WR_{29},WR_{30},WR_{32},WR_{33},WR_{35},WR_{36},WR_{40}$
23	ONU_{23}	$WR_9,WR_{12},WR_{14},WR_{17},WR_{19},WR_{20},WR_{21},WR_{23},WR_{24},WR_{25},WR_{29},WR_{33},WR_{35},WR_{40}$
24	ONU_{24}	$WR_9,WR_{11},WR_{14},WR_{17},WR_{19},WR_{21},WR_{24},WR_{25},WR_{33},WR_{40}$
25	ONU_{25}	$WR_1,WR_9,WR_{11},WR_{14},WR_{15},WR_{17},WR_{21},WR_{24},WR_{25},WR_{40}$

B. Result for Energy Saving Phase

In this phase first we put Head ONUs into awaken mode and rest are in sleep mode. Every Head ONUs maintains a table (shown in table 2). Table gives information that routers connected to how many ONUs and number of it. Traffic is generated randomly on each wireless router. Each Head ONU handle traffic load according to its capacity. If Head ONU feels traffic above its capacity, then first of all, Head ONU identifies those routers from which overload traffic is generating. With the help of table 2, Head ONU gets the information that those routers can communicate to how many other ONUs of the network. Now Head ONU put that ONU in awaken mode which is nearest to those routers. If awaken ONU is also unable to handle that complete overload traffic then Head ONU put another ONU into awaken mode. In this manner the overload traffic is handled by the network. This ONUs will be in awaken state as long as overload traffic is existing in the network. As soon as overload traffic decreases in the network, Head ONU again send these awaken ONUs into sleep mode. For e.g. suppose Head ONU9 feels traffic above its capacity then first it identified those routers from which traffic increases. Suppose traffic increases from routers 13. Now Head ONU shown in table 2 that router 13 connected to how many

ONUs. From Table 2 it is clear that router 13 connected to ONU number 3, 4, 5& 10. Now Head ONU put that ONUs into awaken mode which is nearest to that routers. Head ONU put ONU 5 into awaken mode from sleep mode. This ONU will be in awaken mode until the traffic of Head ONU comes under the capacity of Head ONUs.

Table 2. Number of ONUs connected to wireless routers

S. No.	Wireless Router	Number of ONUs	S. No.	Wireless Router	Number of ONUs
1	WR_1	5,9,10,14,15,19,20,25	21	WR_{21}	18,19,20,23,24,25
2	WR_2	1,2,3,4,6,7,8,11,12,13	22	WR_{22}	4,5,9,10,14,15
3	WR_3	16,17,21,22	23	WR_{23}	6,7,11,12,13,16,17,18,21,22,23,25
4	WR_4	4,5,9,10	24	WR_{24}	7,8,9,10,12,13,14,15,17,18,19,20,23,24
5	WR_5	1,2,3,6,7,8	25	WR_{25}	13,14,15,17,18,19,20,23,24,25
6	WR_6	1,2,3,4,6,7,8	26	WR_{26}	1,2,3,6,7,8
7	WR_7	2,3,4,5,7,8,9,10,14,15,19	27	WR_{27}	16,21,22
8	WR_8	4,5,9,10,14,15,20	28	WR_{28}	3,4,5,8,9,10
9	WR_9	18,19,20,23,24,25	29	WR_{29}	11,12,17,18,21,22,23
10	WR_{10}	1,2,3,6,7,8,11	30	WR_{30}	6,11,12,16,17,21,22
11	WR_{11}	9,10,13,14,15,18,19,20,24,25	31	WR_{31}	3,4,5,8,9,10,14,15,20
12	WR_{12}	3,6,7,8,9,11,12,13,14,16,18,23	32	WR_{32}	6,11,12,16,17,22
13	WR_{13}	3,4,5,10	33	WR_{33}	11,12,13,14,16,17,18,21,22
14	WR_{14}	19,20,23,24,25	34	WR_{34}	2,3,4,5,8,9,10
15	WR_{15}	4,5,8,9,10,13,14,15,18,19,20,25	35	WR_{35}	11,12,16,17,18,21,23
16	WR_{16}	1,2,3,4,6,7,8,9,11,12,13,14,17,18	36	WR_{36}	11,16,17,21,22
17	WR_{17}	15,19,20,23,25	37	WR_{37}	3,4,5,8,9,10,13,14,15,20
18	WR_{18}	1,2,6,7,11,12,16,17	38	WR_{38}	1,2,3,4,6,7,8
19	WR_{19}	17,18,21,22,23,24	39	WR_{39}	4,5,9,10,14,15,19
20	WR_{20}	7,11,12,13,16,17,18,21,22,23	40	WR_{40}	13,14,17,18,19,20,22,23,24,25

IV. CONCLUSION

In FiWi network, **e**nergy Saving is one of the important issues. Increasing number of users and services demand more energy in the network. In this paper an efficient energy saving algorithm is proposed. This algorithm makes minimum number of ONUs into awaken mode. Simulation results proved that proposed algorithm makes energy efficient FiWi network.

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