Survivable Hybrid Wireless-Optical Broadband Access Networks in a Single Segment Failure

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Abstract— Hybrid wireless optical network is gaining popularity because of its wireless features. In WOBAN, the wired part of the access network is replaced with a wireless connectivity Wired router is replaced with wireless router in the network. In a typical network setup, WOBAN consist of servers, optical network unit (ONU), optical line terminal (OLT), routers and node. Back end network of WOBAN is wired optical network and the front end is wireless. Survivability of WOBAN is an important issue. A single segment failure in WOBAN is a scenario where ONU are disconnected with OLT which will lead to large data loss and inconvenience to the users. We are proposing an optimised scheme called optimizing back up ONUs selection and back up fiber deployment (OBOF) to provide survivability of WOBAN in a segment failure. In OBOF scheme simulated annealing algorithm is used for optimising the selection of back up ONU. Enhanced greedy algorithm is used for optimising the fibre layout and channel capacity utilisation. Implementation is done using JAVA

Keywords: WOBAN, Survivability, Optical network, optimisation, PON,OBOF

I. INTRODUCTION

There has been a continuous increase in customer demands for higher bandwidth services with efficient and effective network access. Hybrid technology provides a convenient way of interfacing access networks with point to multipoint optical network known as passive optical network (PON). The architecture is such that, PON connects the telecom central office (CO) to business and residential users by single dedicated channel. The downstream direction is from OLT at CO to ONU and the upstream direction is from ONUs to OLT. PON provides higher bandwidth for data applications and also has deeper fiber penetration. However, PON fails to provide anytime and anywhere Internet connection to the user.

Another emerging technology is Wireless network which provides anywhere Internet connection. There are many wireless emerging technology like 1) wireless fidelity (WIFI) (standards: IEEE 802.11) 2) World Wide Interoperability for Microwave access (WIMAX) (Standards: IEEE 802.16) 3) Cellular network/mobile Network. Each of these techniques has advantages and disadvantages. Wireless network are flexible and can be easily deployed. To provide anytime and anywhere Internet connection hybrid optical network are combined with wireless network which leads to Wireless Optical Broadband Access Network (WOBAN).

The growing needs of the user for Internet demands for higher bandwidth and last mile access network in a cost efficient manner. Thus, wireless optical broadband access network has been proposed to satisfy the growing demands of the user. WOBAN provides high bandwidth and last mile access network in an efficient way with minimum delay in case of segment failure.

This paper reviews in brief our work on WOBAN. Section 2 gives details on the WOBAN Architecture, Section 3 gives details on OBOF Scheme, Section 4 gives description of Algorithm used in WOBAN, Section 5 Technology used ,Section 6 gives details of OBOF Scheme Working and Result Analysis and Section 7 gives conclusion.

II. WOBAN ARCHITECTURE

In a passive optical network, it's very costly to deploy a fiber from telecom central office (CO) to end user. It is also not possible to provide a wireless access from CO to every end user because of limited spectrum. The WOBAN solves the above problem by deploying fiber as far as possible from the CO and then having wireless path to the end user. The wireless access technologies reduce fiber deployment cost and provide more flexibility.

The concept of hybrid wireless optical broadband access network (WOBAN) is very attractive. It enable user to access Internet anywhere in a flexible manner. WOBAN architecture is shown in Fig 1. The network is divided into multiple segments. Each segment consists of Optical network unit (ONU), optical line terminal (OLT) and wireless routers.

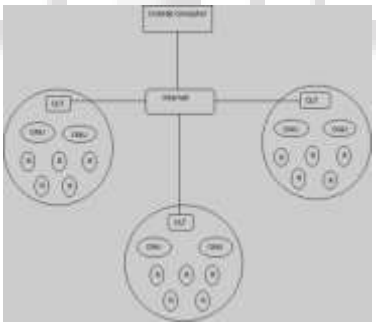

Fig. 1: WOBAN Architecture

The front end of each WOBAN segment is a wireless mesh network with wireless technologies like WIFI and WIMAX supported by passive optical network at the back end. Wireless mesh network consists of several wireless routers, gateways. The PON segment is driven by optical line terminal (OLT) which is situated at central office. The end/tail of each passive optical network segment contains a number of ONU. ONU acts as an interface between optical back end and wireless front end. Apart from receiving and transmitting optical signal, a ONU converts wireless signals to optical signal and vice -versa.

In WOBAN upstream direction end users are subscribed with wireless devices. From end users, data is transferred to its nearest wireless router. The router forwards the packets to the WOBAN wireless mesh network. In WOBAN, the packets travel to one of the ONU, then to the optical part of the WOBAN that is OLT, from there to the

destination end user. In downstream direction, WOBAN is a broadcast network where a received packet from destination is broad cast to all the ONUs in tree format and is processed selectively to one of the destination ONU. Then packets are forwarded via wireless router to the destination end user.

WOBAN carries a large amount of traffic. Some times traffic flow gets disturbed because of the failure of the network components. So, enhancing the survivability of the WOBAN is a key issue. As explained in WOBAN architecture, the front end of WOBAN is wireless mesh network and back end is optical network. In case of any failure in front end, it is self healing because it can provide alternate routes however in case of back end which is an optical network is a tree topology any failure like distributed fiber will not allow any data packets to move further. However, in case of segment failure which can be feeder fiber or distributed fiber the ONU in the failed segment losses its connection with OLT and no data transfers from source to destination.

Considering the problem mentioned above some protection schemes are proposed.

1) Wireless multi-hop paths are established across different segments in a network to transfer interrupted traffic from failed segment to available segment. But this scheme fails because segments are so far that wireless path cannot be provided even wireless path is available, it will take much longer time to transfer the interrupted traffic.
2) To overcome all the problems mentioned above, a new optimizing back up ONUs selection and back up fiber deployment (OBOF) scheme is proposed for survivability of Hybrid wireless optical network.

III. OBOF SCHEME CONCEPT

In this section, a new scheme is proposed for optimizing back up ONUs selection and back up fiber deployment .OBOF scheme consists of two steps.

1) In the first step, simulated Annealing (SA) Algorithm is applied to optimize the selection of back up ONUs in segment to store the interrupted traffic and to redirect the interrupted traffic to other available neighbouring segment.
2) In the second step, Enhanced Greedy Cost Efficiency (EGCE) algorithm is applied to optimize deployment of backup fiber between the backup ONUs of neighbouring segment.

In this paper, we have demonstrated OBOF scheme on windows platform using Java language with Eclipse IDE and SQLYOG database.

IV. ALGORITHM

A. Simulated annealing algorithm

Simulated Annealing is a meta-heuristic non-linear algorithm. It's based on random search technique that is random number generator. A significant component of an SA algorithm is random number generator. It is important particularly when tackling large scale problems which require thousands of iterations. SA algorithm is robust and good spectral technique.

In this paper, we are using SA algorithm to solve optimizing problem that is computationally complex. In this algorithm, we define the solution space as all ONUs in a segment and optimal solution is the ONU who has minimum recovery cost. Initially, an ONU is randomly selected as the current solution then the current solution will be updated with the new ONU having less recovery cost compared to previous ONU. In this way a better solution is found.

In this process, the SA algorithm initially selects an ONU randomly as backup ONU (current solution) in a segment. This is represented as Si= {1, 2, 3……n}. Specifically in each iteration one of the ONU is randomly selected as new ONU which is then compared with the current ONU.

1) If the recovery cost of the new ONU is less than the current ONU, then the new ONU will be updated as current ONU.
2) Otherwise, if new ONU recovery cost is greater than current ONU, then new ONU will be rejected. This process keeps on iterating until all the ONUs in a segment are compared. In this way, an ONU is selected as back up ONU which is having low recovery cost compared to all other ONU in a segment and the other ONUs in a segment are called general ONU. This process repeats for all other segments in a network. In this way, a backup ONU is selected in all the segments. In case of a failure in any segment, the traffic from general ONU is redirected to backup ONU.

B. Enhanced greedy cost efficiency algorithm

Enhanced greedy cost efficiency algorithm is proposed to improve the residual capacity utilization of the segments thus maximizing the amount of protected traffic.

EGCE algorithm is used to solve the maximum protection minimum cost remote backup segment problem. EGCE algorithm deploys backup fibers between neighboring segments to redirect the traffic from the failed segment to neighboring segment .EGCE finds out the neighboring segment pair from the set of candidate neighbor segment pair (si….sj), aiming to minimize fiber cost. Candidate neighboring segments are defined as segments that can support valid deployment of back up fiber between them.SA algorithm allocates the backup ONUs in each segment. Now EGCE algorithm deploy, back up fiber between back up ONUs of different segments in a greedy manner. All the segments in a group are connected by back up fiber. Once the kth (k=1, 2, 3…) backup fiber is deployed, the minimum length of the backup fiber is updated.

Two novel methods are proposed to improve the residual capacity of the segment and to minimize the recovery time or optimizing backup fiber deployment.

Remote Backup Segment method (RBS): The RBS method is used to protect a segment by its remote neighboring segments through back up optical path.

Bound on the length of Back up optical path (BLB): The larger BLB implies that each segment will have more backup segments. Thus, residual capacities of more segments are utilized in an efficient manner. Sometimes, it also leads to longer recovery time that is delay in transferring the interrupted traffic. In RBS, longer length of back up optical path may lead to longer time to recover interrupted traffic introduces a delay. Therefore, the BLB acts as a recovery time constraint and EGCE algorithm imposes limit on the length of back up optical paths between

the failed segment and the remote segment (backup segment).

V. TECHNOLOGY USED

A. JAVA

Java is a set of several computer software products and has specifications from Sun Microsystems (which has since merged with Oracle Corporation), that together provide a system for developing application software and deploying it in a cross-platform computing environment. Java is used in a wide variety of computing platforms Java applets are sometimes used to provide improved and secure functions while browsing the World Wide Web on desktop computers. Writing in the Java programming language is the primary way to produce code that will be deployed as Java byte code. Several new languages have been designed to run natively on the Java Virtual Machine (JVM). Java syntax borrows heavily from C and C++, but object-oriented features are modelled after Smalltalk .Memory management is handled through integrated automatic garbage collection performed by the JVM.

Programming languages are typically outside of the scope of the phrase "platform", although the Java programming language is listed as a core part of the Java platform. The language and runtime are therefore commonly considered a single unit. The Java Development Kit (JDK) is a Sun product aimed at Java developers. Since the introduction of Java, it has been by far the most widely used Java software development kit (SDK). It contains a Java compiler, a full copy of the Java Runtime Environment (JRE), and many other important development tools.

B. Eclipse

In computer programming, Eclipse is a multi-language Integrated development environment (IDE) comprising a base workspace and an extensible plug-in system for customizing the environment. It's a language neutral, integrated development environment (IDE) for building, and managing software across the entire software life cycle. It is written mostly in Java. The Eclipse software development kit (SDK), which includes the Java development tools, is meant for Java developers. Users can extend its abilities by installing plug-ins written for the Eclipse Platform, such as development toolkits for other programming languages, and can write and contribute their own plug-in modules.

The Eclipse Software Development Kit contains everything you need to build Java applications. Considered by many to be the best Java development tool available, the Eclipse Java Development Tools provides superior Java editing with on-the-fly validation, incremental compilation, cross-referencing, code assist and much more.

C. Sqlyog

SQLyog is a GUI tool for the RDBMS MySQL. It is created by the software development company Webyog, based in Bangalore, India and Santa. SQLyog is an easy to use, compact and very fast graphical tool to manage your MySQL database anywhere in the world. SQLyog is a tool that allows you manage MySQL database. Import data from ODBC data source, synchronize your database. Execute queries for updating of result, Copy databases between hosts. Generate Schema for your database. Manage Foreign Relationships and all options. SQLyog is the most powerful MySQL manager and admin tool, combining the features of MySQL Administrator, phpMyAdmin and other MySQL Front Ends. It contains MySQL Query Browser and MySQL GUI tools in a single intuitive interface. SQLyog is an easy to use, compact and very fast graphical tool for managing your MySQL databases.

VI. OBOF SCHEME WORKING AND RESULT ANALYSIS

For an efficient transfer of the data in a network, optimizing backup ONU selection and back up fiber deployment (OBOF) scheme is applied.

Considering that there are three segments in a network s1, s2, s3 and in each network cell

1) Each segment carries 500 bytes of data.
2) Each segment has enough capacity to carry the interrupted traffic.
3) There will be only single segment failure.
4) Back up fiber does not fail when there is segment failure.

Considering that segment s1 in a network fails then in OBOF scheme, when the primary ONU encounters the segment failure (e.g., caused by feeder fiber failure or all distribution fibers failure), it sends the failure report messages to the backup ONU of the failed segment selected by SA algorithm through the wireless front-end. The backup ONU, upon receiving the failure report messages, activates its traffic recovery functionality and then replies the confirm messages to the primary ONUs through the wireless front-end. Thereafter, the available wireless paths are established between the primary ONUs and the backup ONU. In order to recover the traffic interrupted by failure, the primary ONUs can use the wireless paths to transfer the interrupted traffic to the backup ONU.

Once interrupted traffic is stored in back up ONU, the EDGE algorithm finds the neighboring segment pair and deploys a back up fiber between the failed segment and neighboring segments pairs. Neighboring segment for s1 is selected based on two factors, the distance and the available traffic of the segment. Consider that s1, s2, s3 are back up for each other. The interrupted traffic is now redirected to selected neighboring segment of s1 that is s2.If the residual capacity of s2 is not enough to fully protect the traffic from s1 then it's also possible to send the interrupted traffic to more than one neighboring segment. That is, s1 can also send the interrupted traffic to both s2 and s3.Then, both the segments s2, s3 carry the interrupted traffic of s1.

The optimality of a candidate neighboring segment pair is measured by cost efficiency. Cost efficiency can be regarded as the amount of traffic protected by per unit of back up fiber between each pair of segments.

It's demonstrated that our OBOF scheme is efficient in saving back up fibers cost and SA algorithm is more efficient than random methods in selecting back up fiber. Because the optimal solution of the segments cannot be calculated within reasonable time in large scale network

In this paper, we have demonstrated OBOF scheme on windows platform using Java language with Eclipse IDE and SQLYOG database.

VII. CONCLUSION

In this paper, OBOF scheme is demonstrated to enhance the survivability of WOBAN against single segment failure in a

network and optimizing backup ONU selection and backup fiber deployment. In our scheme 1) we have optimized the settings of SA parameters (in the first step of OBOF) and BLB (in the second step of OBOF) to improve the performance of OBOF 2) In this paper OBOF scheme optimizes ONUs. In OBOF scheme ONUs are used to transfer data packets and interrupted traffic to the destination and it also act as storage unit, it stores the interrupted traffic in this way OBOF scheme is effective in saving backup cost. 3) OBOF scheme provides a little delay to transfer interrupted traffic by redirecting interrupted traffic to available neighbouring segments.

In our future work, we will investigate traffic recovery scheme in real time system and to enhance traffic recovery time. The optical part of wireless optical network is having high capacity. We need to enhance the capacity of wireless using low cost.

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