MINIMIZING ENERGY WITH HIGH-SPEED WDM OPTICAL GRID NETWORKS

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Abstract
In the existing optical network, WDM technology transfers information with different wavelengths. Several researchers previously focused on increased wavelength capacity in optical networks. The optical network of WDM technology ranges from 1 to 2.5 GB/S & 10 to 40 GB/S. with the increasing WDM range level; it can be extended up to 400 GB/S. The previous 100 GHz grid networks used in WDM are not feasible solutions for transceiver applications. The traffic manipulation of multiple signals in WDM will cause lower system efficiency. The key difference is the fast response by transponders which allows high efficiency for spectrum modulation, but it will not fitted within 50GHz slot of frequency modulation spectrum due to large spectrum modulation requirement. The crucial benefit of adopting flex grid network is it will offers spectrum efficient modulation & finer control in spectrum allocation. It also provides better control on WDM network with effective traffic management. In this paper, flex grid & fix grid networks are used for internet networks to minimize energy usage in the system. In this project work, optical network planning & operation control helps with the operation of both grid network configurations.
Keywords—WDM, OFDM, Flex Grid & Fix Grid, etc.

1. INTRODUCTION
In recent time the optical fiber network is operates on WDM technology with information transfer on different range & different wavelengths. I studied that previous researchers have focused the traffic management of WDM & optical network through increasing the wavelength of signals. The increase of wavelength requires wide range receiver with 100 GB/s range & in next few years it will crosses 400 GB/s step with more complex network configurations. This kind of transmission will not fit for 50 GHz wavelength in WDM networks [2-4]. After some of researchers is designed 75 to 100 GHz range for transceivers in optical network. But all of those are very limited solution & not possible to use for wide range of optical network applications. At the other hand WDM network faces low efficiency problem due to coarse granularity of the light paths in optical network operations. Due to this issue optical connections & their operation in WDM network becomes very complex for whole wavelength.
Traffic manipulation at lower capacity levels is performed at the electronic. The traffic manipulation of multiple signals in WDM will cause lower system efficiency. This Paper studied the data records for internet use & Global Internet traffic growth increase in recent years. From that study, I learned that multiple 300 times more GB/s increases GIT growth. Using Flex-gird will help meet the requirements of internet networks for the next generations. While the use of fix grid network provides fixed bit data rate transfer in the communication network in the system. The data patterns are also maintained in the specified manners in the limited grid network, while the data patterns are in unexpected ways in the flex grid network. This paper studied all research materials on flex & fix grid networks for optical internet networks with features of energy use reduction [4].

This Paper characterized the benefits of a flex grid network for managing the flexible operation of internet sources. To increase network capacity, the Flex grid requires a less rigid and fixed approach to wavelength allocation. Flex grid networks can natively support demands greater than 100Gbit/s demands, which is a key benefit and brings significant capacity benefits on both a point-to-point link and in a network context. This Paper is a detailed study of the use of WDM networks for internet use. It helps me to manage the project objectives to carry out during this work [1-2].

- ✓ To study the benefits of Flex grid network compared to fix grid network for WDM network.
- ✓ To carry out the study on the operational block diagram of the project idea.
- ✓ To develop the Matlab coding & implementation for simulation analysis of both types of grid networks.

2. RESEARCH GAP & OBJECTIVES

This work presents the exponential growth of internet in past few years, this large usage of internet leads us to think about grid network operations. This paper work presents the use of fix grid & flexes grid networks in optical network to solve the traffic issues, various wavelength signal modulation, power saving, etc. In this paper the operational structure of fix grid & flex grid network is studied for energy consumption & power saving with analytical model study. I have applied the study of these analytical models for real topologies with internet traffic management. In the previous studies several researchers have proposed CAPEX/OPEX model based solutions with energy optimization algorithms. [1-3]But due to their limitations & complexity for wide range of wavelength modulation control in WDM network, I have focused to extend my work fix grid & flex grid based operation for WDM system with location based energy pricing system. This will helps to significantly monitoring of energy use & adjustment in reducing the power consumptions in optical network system. With the development of technological advancement, internet use is also rapidly increasing. The internet will consume electricity for devices to operate the board band network. The ICT use with telecommunication will control energy consumption under control [2-4]. In the present scenario, in this Paper researcher studied that broadband-enabled countries use around 4% of total energy consumption, and in the optical network, energy consumption is around 12%. This Paper planned to develop a feasible grid network for the internet to reduce energy use in the system. I learned that there are flex grid & fix grid networks are used for internet networks to minimize energy usage in the system. In this project work, optical network planning & operation control helps with the operation of both grid network configurations. The proposed formulation is quite generic and can be used to allocate resources when sliceable transponders are used, but also for fixed transponders of single or mixed line rate and fixed grid switch [4-5]. Using a flexible grid network, I also studied that optical network planning can be implemented with low energy consumption. Appropriately planning the algorithm is essential to develop Matlab coding for the proposed system to check the performance comparison. This Paper studied that still in developing countries, internet speed is deficient. As time goes by, they require high-speed internet in upcoming times for data transfer and reliable operation.

In the future, technological advancement is focused on developing an internet channel for 400 GB/s. An existing fixed grid WDM network can't achieve this internet speed. To enhance the speed level flex grid network is feasible for increasing the internet speed in this research work. This Paper planned Matlab simulation work with coding implementation for flex grid network and studying bandwidth signal multiplexing. This Paper used communication ideas to develop the energy-aware algorithm for a flexible

grid network with SLR & MLR spectrum for transmitting high bit rate data in the channel system. This Paper developed the Matlab coding of the proposed algorithm to test the performance of the fixed grid & flex grid for maximum data transfer. It helps me improve communication network fundamentals for internet networks [6].

3. FLEX GRID & FIXED GRID NETWORKS

3.1 Fixed Grid Network Operations

In the latest, all researchers focused on variable spectrum connections to improve spectral efficiency and large bit rate data transfer in the system. But the existing fixed grid network will not provide such a variable spectrum causing the limited use of optical internet networks [1-2].

This Paper studied the basic operational configuration of a fixed grid network that provides a fixed spectrum frequency for WDM networks. It required modulation & several OFDM techniques for the modulation of channel signals. For the use of fixed grid ROADM operation, they will follow the traditional grid network in communication networks. The conventional networks will provide fixed frequency levels for the operations around 50 to 100 GHz for individual channels. The fixed grid system will use multiple devices for variable spectrum applications at receiving end, including optical switches, multiplexers, transponders, etc. The wavelength spectrum & diagram for the essential operation of the fixed grid network are shown below.

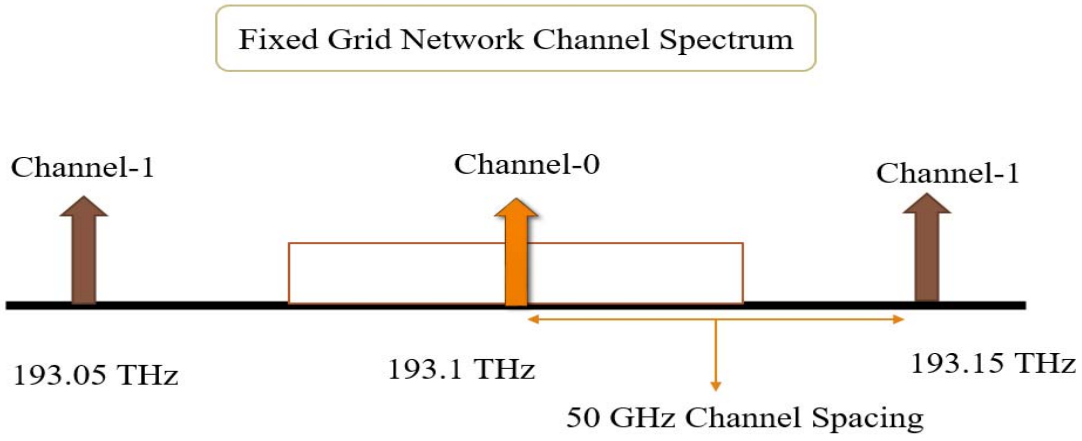

Fig.1 Operational Diagram of Fixed Grid Network

The main drawback of a fixed grid network is the RWA problem which causes the limited bandwidth of the signal. WDM was only designed for SLR with a single transponder for the optical network in a fixed grid network. But the new advancement in transmission technologies is required to adopt multiple transponders to improve efficiency & reduce network costs. These kinds of multiple transponders will be called MLR for the optical network system. This Paper studied that MLR benefits will be focused on the WDM system with flexible grid network use for upcoming times. The flexible grid network provides multiple frequency band signals for modulation and multiplexing of various frequency ranges for signal.

3.2 Flex Grid Network Operations

This Paper specified earlier that a flex grid network has several benefits compared to a fixed grid network. But the only problem with a flex grid network is that establishing a flex grid is more complicated than a fixed grid. Compared with the fixed grid network where a single wavelength is used, the flex grid has spectrum slots with combination forms with different width channels. Therefore, it is also known as RSA for spectrum allocation in the optical system. This Paper also worked on a different range of transmission options & various fields of spectrum use for RWA and RSA spectrum sampling.

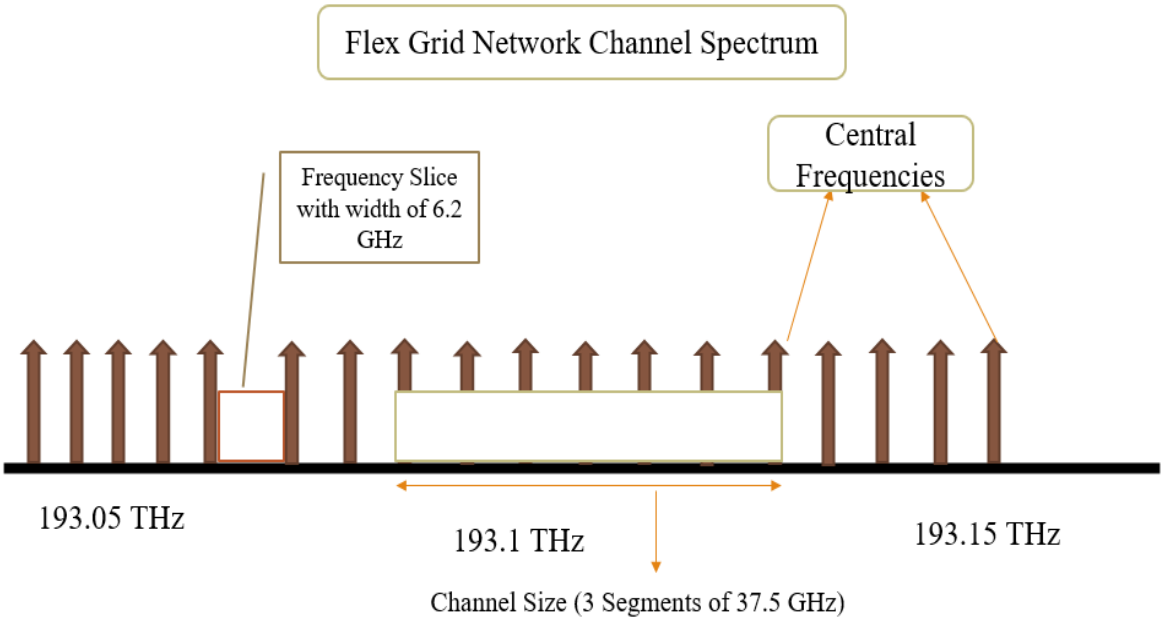

Fig.2 Operational Diagram of Flex Grid Network

WDM transceivers are used for specific signal transmission with other signal interference control with useful OFDM technologies. In the proposed flex grid network, the data transmission rate depends on the configuration of BVT & regenerators in the optical network system. For example, a flexible-grid node uses only 25 GHz spectrum resources instead of 50 GHz to transmit a 40 GB/s signal, which saves spectrum resources. As shown in fig. 3 above, the signal spectrum will show the multiple signal multiplexing & an extensive range of frequencies in the operation of flex grid network operations.

4. SIMULATION & ANALYSIS

4.1 Matlab Coding of Proposed Grid Networks

For developing the WDM optical network model, this Paper worked on tutorial & demo models of Matlab coding to start the communication network work. The optical network coding will include all parameters results analysis like dispersion, intensity, fiber optics efficiency, and many more. As shown in the figure below, in this Paper calculated the modal dispersion in the fiber network concerning the signal's wavelength. All the other case studies and results are carried out in the below section. The diameter is considered with various ranges to calculate the modal dispersion $\eta_{eff}$for the different wavelengths of signals [1-3].

This Paper tested multiple ranges of applications for the proposed WDM network in this Matlab coding. It helps me characterize the optical network's performance with results analysis. This Paper also prepared different tutorial models in Matlab coding for this project which is also helpful in developing the comparative study of flex grid & fixed grid performance.

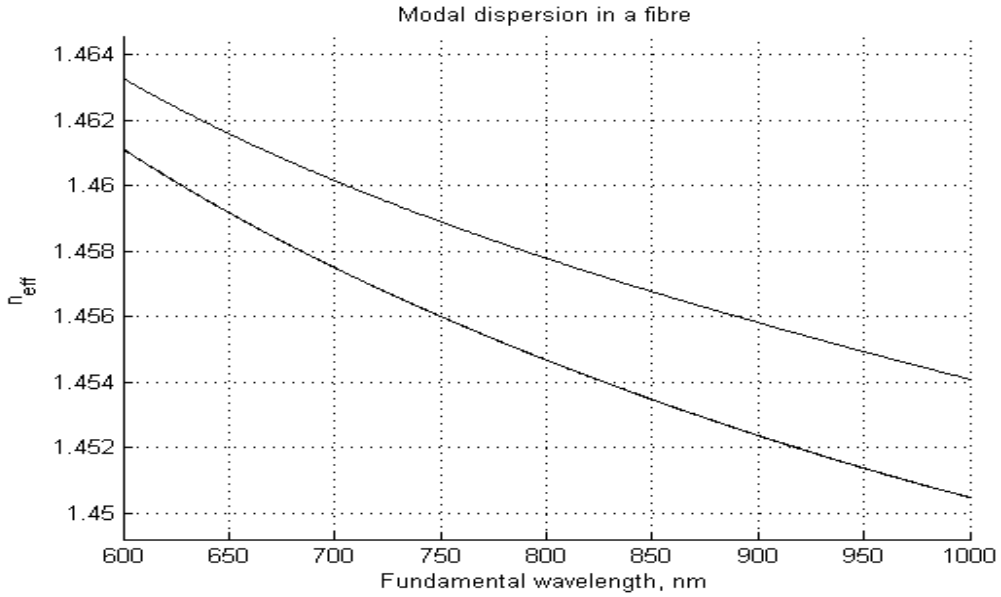

Fig.3- Modal Dispersion in Optical fiber network w.r.t wavelength

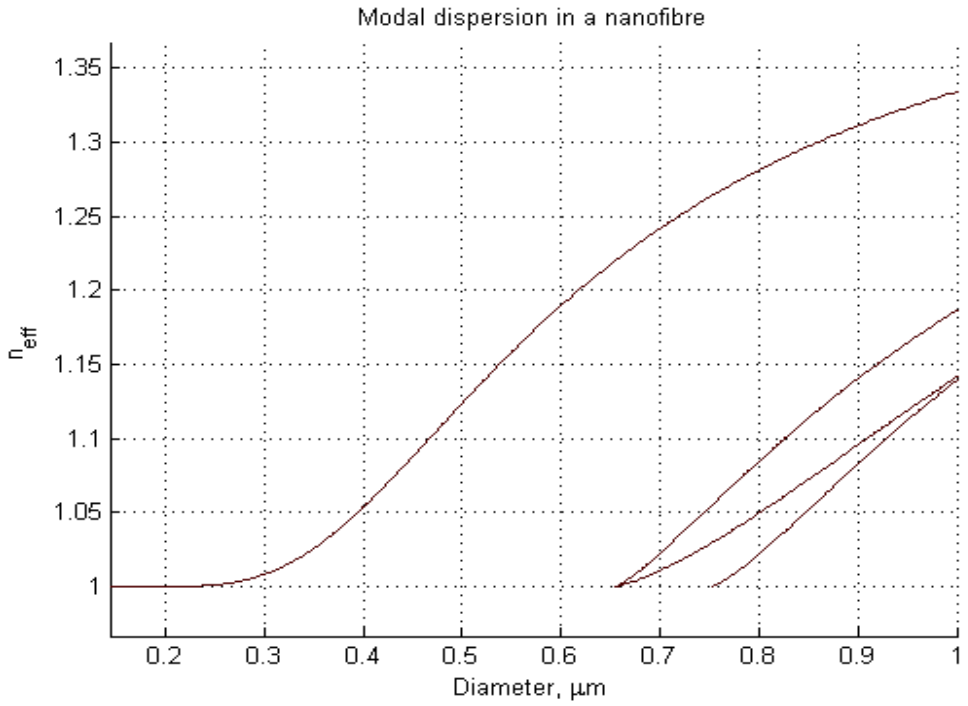

Fig.4- Change in Modal dispersion with diameter change

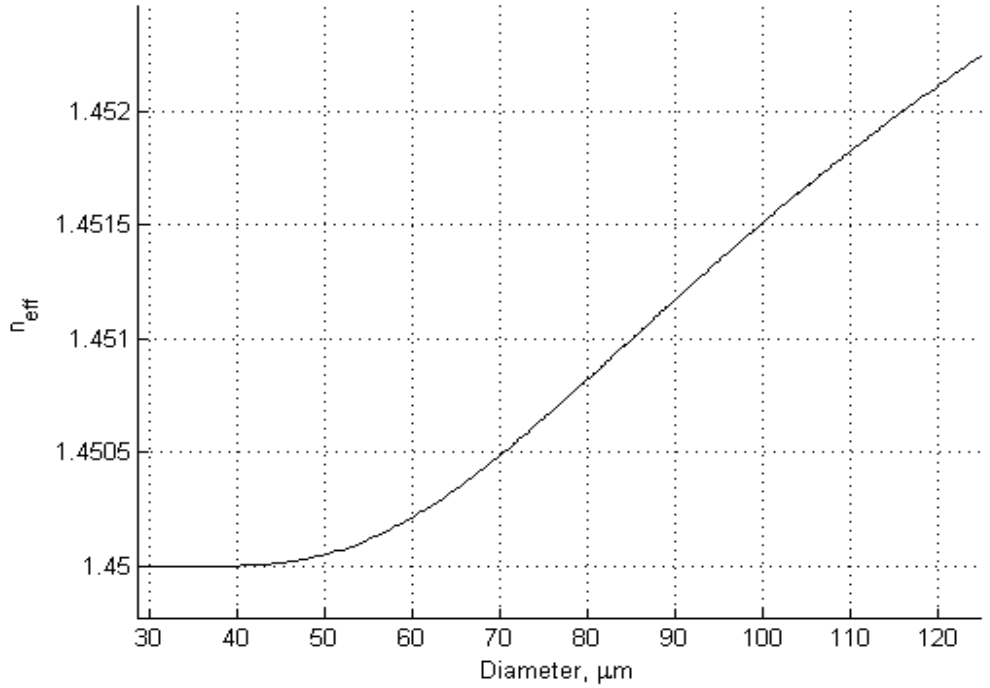

Fig.5- Results of η_{eff} with the fiber diameter range

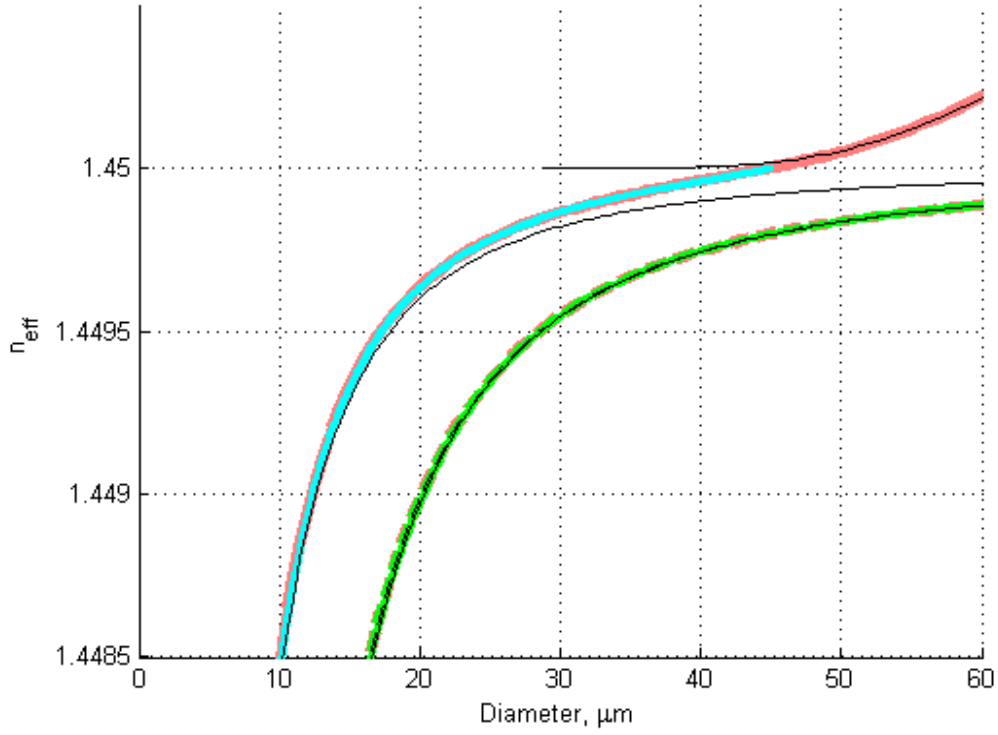

Fig.6- various signals modal dispersion η_{eff} with fiber diameter range in WDM

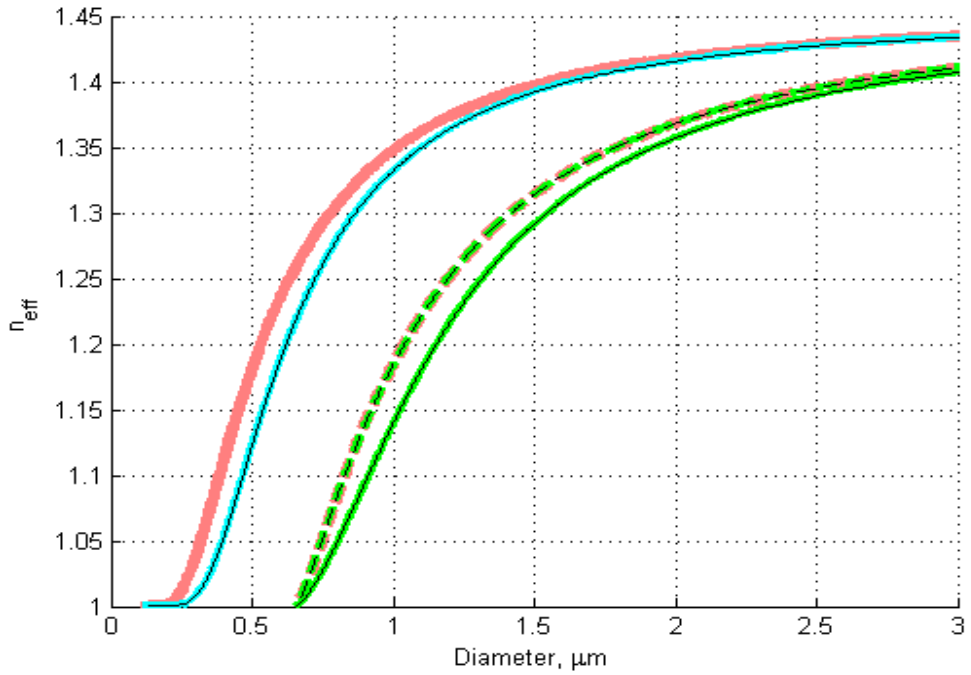

Fig.7- various signals modal dispersion η_{eff} with fiber diameter range in WDM Case study-I

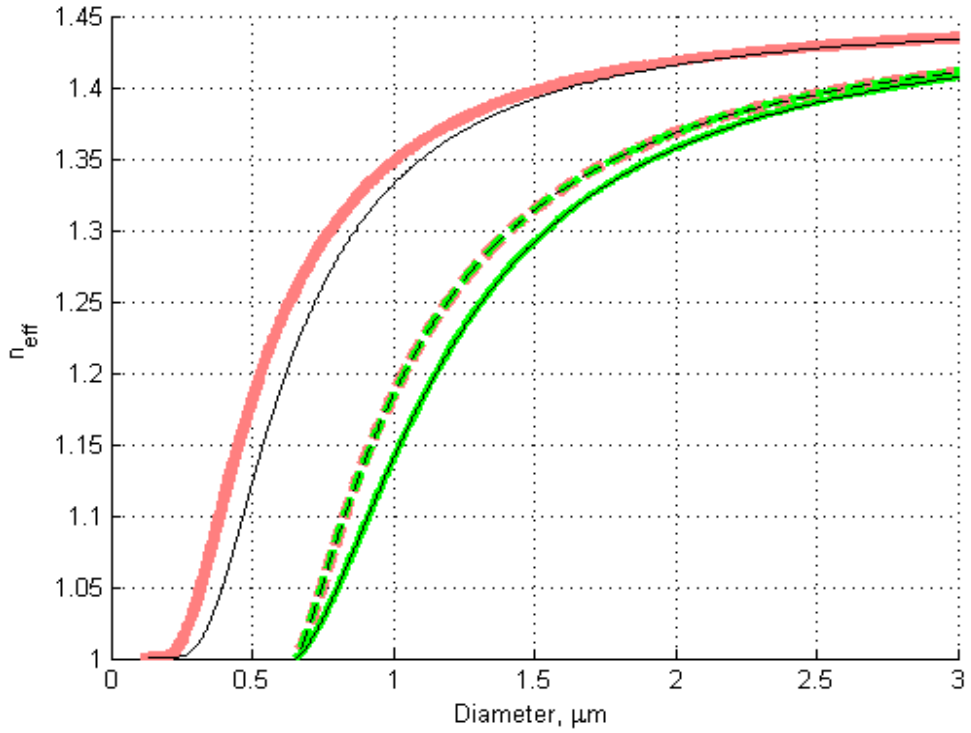

Fig.8- various signals modal dispersion η_{eff} with fiber diameter range in WDM Case study-II

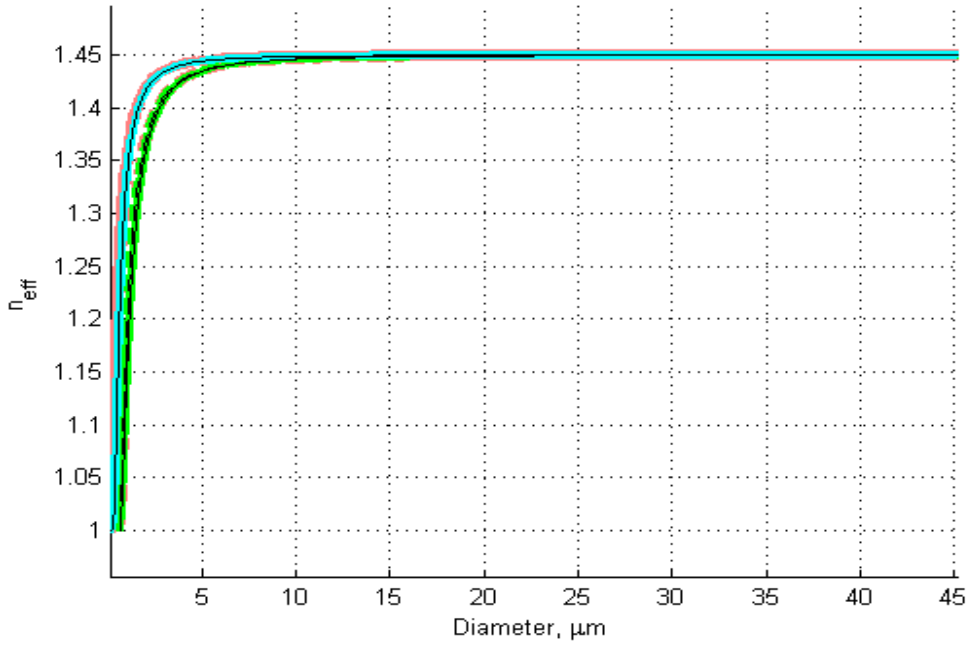

Fig.9- various signals modal dispersion η_{eff} with fiber diameter range in WDM Case study-III

4.2 Performance Comparison

For the comparative analysis of both types of grid network configurations, in this Paper performed the simulator model developed for the WDM network model. Various nodes are used to multiplex the signals in flexible mode, shown in the results below.

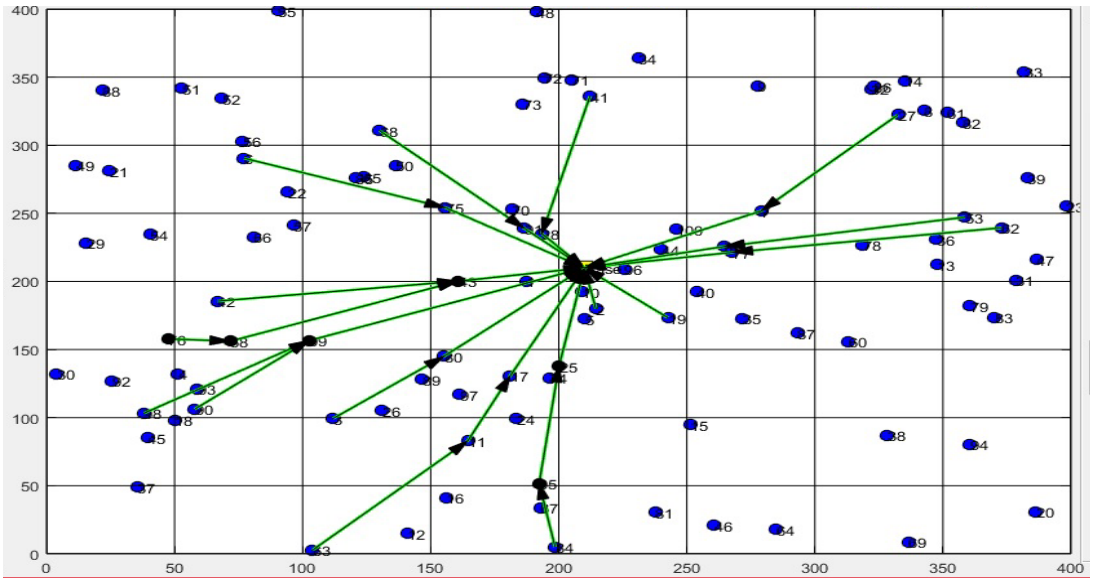

Fig.10 Flex Gird multiplex with the number of nodes in the simulator

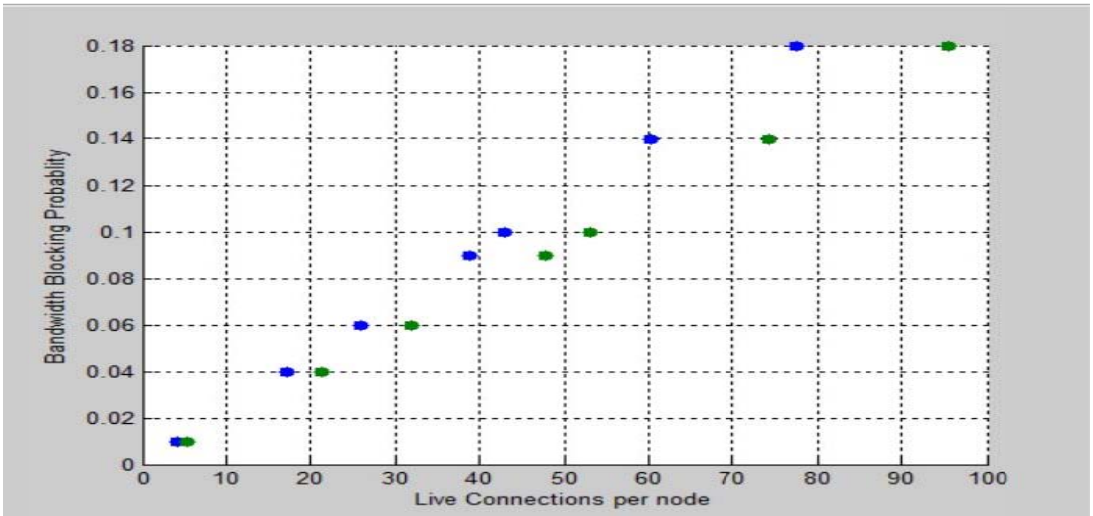

Fig.11- Comparison of Flex grid to Fixed Grid

The above-shown fig.11 compares the Flex grid to the fixed grid, in this idea I have develop the poison process with negative exponential algorithm to create these both gird networks. In this Matlab system design I have use frequency slot for 12.5 GHz with variable range of 1 to 12 GHz in the flex grid network. While for fixed grid network I have maintained frequency level for 8 GHz for the WDM operation. At the same time for performance comparison I have adopted frequency range for 12.5 GHz slot even in the Fix grid. This will helps us compare both grid network methods easily. I have discarded the option of 50 GHz because it won't be a modern approach wherein we are trying to use a frequency slot of only 12.5 GHz. As seen from the above figure, the Green dots are of the Flex grid network, which shows that we can provide more live connections using the flex grid method. Loads on the network include inter-arrival time, Holding time, live connections & other random parameters that come with a grid network. The comparison shows us that the Flex grid better utilizes provided frequency slots.

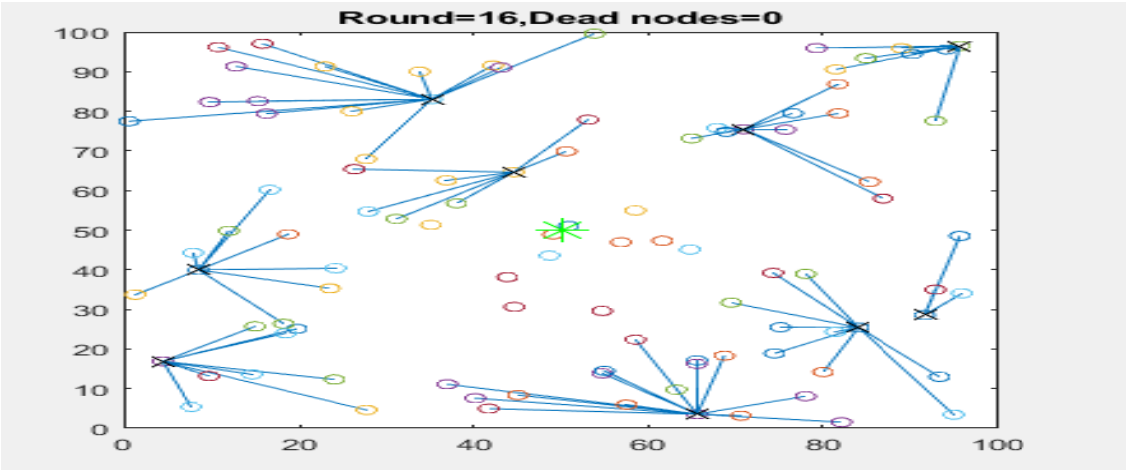

Fig.12- Test results of flex grid with multiple nodes for 16 Rounds

Conclusion

The continuous growth of the internet will focus on research on the energy consumption of internet devices & infrastructures. The broadband networks & optical networks are consumed 4% to 12% of total

energy consumption. If any effective grid network is not developed for the WDM network, then the efficiency level & performance level of internet speed is deficient. This Paper studied multiple ideas to achieve in this work, including high-speed internet and reduced energy use with a flex grid network. In this project, this Paper managed network performance with individual power consumption control with analytical models of flex grid models. This Paper performed the Matlab coding & simulation of the WDM network for the energy consumption of a fixed- or flex-grid optical layer proposed in this work. It will summarize that adopting a fixed-to-flex grid model will help increase internet speed with multiple node frequency modulations. It will also help to reduce the energy levels in the WDM network. The work expansion of this flex grid network adoption can be added in terms of SNR with amplifiers use. It will reduce the noise ratio & signal disturbances in the network, ultimately enhancing the proposed system's efficiency level.

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