A Review of Routing Algorithms and their extensions for Optical Networks

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Abstract— The execution of an interconnection network is profoundly affected by specific properties of the directing calculation which are being utilized. This paper manages the investigation of the directing calculations proposed and survivability in writing for optical systems. This paper gives the concise writing survey on the point what's more, finished up with a portion of the work which should be possible in this zone. Aim is to get a review of the work done on various optical routing algorithms to get an idea of the work and then to get further extensions. Wavelength Division Multiplexing (WDM) is as of now a reality for optical transmission frameworks with numerous sellers offering arrangements and modifications.

Keywords— Wave Length Division Multiplexing, SONET, Routing and Wavelength Allocation (RWA), Genetic Algorithm.

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1. INTRODUCTION

A Routing calculation sets up the ways that messages must take after to achieve their goal. The execution of a network is impacted by specific properties of the directing calculation utilized. Among these properties, two are of more prominent significance, stop what's more, live-bolt opportunity and adaptivity. Adaptivity is the capacity of a directing calculation to course bundles through elective ways in the nearness of dispute or flawed segments. This is against deterministic steering in which a message, beginning at a particular source hub, is constantly steered through a similar way to come to a particular goal.

Wavelength Division Multiplexing (WDM) is now available with, at least 16, channels, at bit rates of up to 10Gb/s. These frameworks are basically static and point-to-point, with the WDM giving a practical approach to build limit. The challenge now is to capitalise on the move beyond WDM and find new ways in which network features can be expanded whilst cost is reduced. Customarily WDM has been focused at the whole deal advertise where the primary point has been to transport the most extreme number of bits at the base cost. In any case, as the cost of parts diminishes the open doors in the metropolitan and access markets will increment permitting arrangements which are streamlined for specific specialty applications to be created. At the point when the high cost of fiber establishment is viewed as the aggregate use on the terminal might be a moderately little part contrasted with that of the aggregate system. The high limit (different STM64 or STM16 channels) implies that security of the information is required. This can be given by SONET and SDH where an extremely strong security system at the line rate is offered, reestablishing the association inside 50ms. In the short term optical provisioning is not appealing on the grounds that the measure of pal at OC48/STM16 or OC192/STM64 is little, be that as it may, the capacity to give security or rebuilding at the optical layer could be exceptionally appealing in decreasing expense and expanding system effectiveness for a few rising applications. WDM is presently moving towards the supposed systems where separations are not really expansive (ordinarily <100km), activity requests are more changed (100Mb/s to 5Gb/s) and the terminal cost is probably going to command over that of fiber and intensifiers. A scope of designs can be imagined from completely coincided to straight, and it is additionally conceivable that the pal at the line rate will be higher making optical provisioning more alluring. The further section of the paper provide a review of major work done in the area of Optical network routing algorithm. The next section discusses various advanced features and extensions proposed for optical networks.

2. REVIEW OF LITERATURE

Paths having the greatest number of accessible wavelengths between two nodes, as advocated by **Y.Younghwanet al.** [14], encourage better load distribution. Simulated results were compared to various small network routing strategies, such as least-loaded. The suggested methods were simulated using a first-fit wavelength assignment methodology.

The blocking performance of the network is improved by the adaptive routing methods provided by **Mokhtaret. al.** [1]. Circuit switching is taken into account together with routing and wavelength assignment. When making routing decisions, they used a comprehensive strategy that takes into account all possible routes between a pair of source–destination nodes (s–d). This method is used to route traffic and allocate wavelengths. They also provided and tested techniques for adaptive routing and wavelength assignment for blocking. For networks with fixed and alternative routing, they have also developed an analytical method to estimate blockage probability.

R. Ramaswamiet. al. [11], studied the issue of wavelength division multiplexing (WDM)-based network connection routing. For each routing or wavelength assignment mechanism in a network, they came up with an upper bound on the carried traffic of links.

G. Mohan et. al. [5], Re-routing of wavelengths in WDM networks with circuit switching has been discussed. In response to a random pattern of arrival requests, the light routes between source and destination pairs were dynamically formed and released. For WDM networks with wavelength routing, they also provided a method for rerouting wavelengths efficiently using a technique called Move-to-Vacant-Wavelength-Retuning (MTV-WR)..

X. Chu et. al. [12], suggested a method for rerouting traffic in legacy circuit-switched networks in order to reduce the blockage likelihood. In all-optical WDM mesh networks, they also introduced purposeful light path rerouting.

R. Ramamurthy et. al. [10], An approximate analytical model incorporating alternative routing and sparse wavelength conversion has been suggested. With the use of cross-connects, they proposed an optical network with wavelength-division multiplexed connections between nodes. Three sample network topologies were used in the simulations to examine the connections between alternative routing and wavelength conversion.

H.Haraiet. al. [3], A dynamic routing technique for all-optical switching networks was developed after a thorough investigation of existing routing methods. Connections that have more hops are more likely to be blocked in all-optical switching networks with no wavelength conversions. Limited trunk reservations were proposed for a different routing strategy. Using an approximate mathematical technique, they demonstrated that their solution outperforms existing alternative routing approaches in terms of performance.

W. Yaoet. al. [16], Researched and presented several rerouting strategies for the provision of multigranularity connections in two-layer wavelength-routed optical networks with grooming capabilities in the approach to rerouting. They took into account the constantly changing flow of traffic and the fluctuating number of requests for connections.

L.Guoet. al. [8], based on the notion of rerouting optimization, two heuristics were presented. In order to avoid single link failure in wavelength division multiplexed mesh networks, they studied the challenge of providing resilient routing and suggested a fast online heuristic based on Mixed Shared Path Protection(MSPP) to offer resilient routing for each connection request.

K.C. Lee et. al. [7], various methods for circuit arrival and departure rerouting in a wide-area, all-optical WDM network and reduced the interruption caused by circuit rerouting. In order to accommodate a new circuit, some existing circuits may need to be rearranged to produce a wavelength-continuous path. MTVWR is working to minimise the amount of time that this may cause problems. migrating one circuit to another on the same line and using parallel MTV-WR routing to move many other circuits was employed as the primary operation of circuit migration.. The weighted number of rerouted circuits with concurrent MTV-WR rerouting was minimised using an optimum method devised. A branch-and-exchange (BE) method was also created to reduce the amount of BE operations required to convert the existing network topology to the target network topology. There is a novel circuit migration technique for rerouting circuits that has been developed to considerably shorten the disturbance duration in wavelength rerouting.

X. Chuet. al. [13], researched the rerouting of light paths in optical WDM networks and analysed passive and purposeful rerouting solutions. They came to the conclusion that path-adjustment can be employed for full wavelength convertible network rerouting and wavelength retuning can be used for wavelength non-convertible network blocking performance improvement. Rerouting can help, but not as much as wavelength-retuning in terms of blocking performance.

3. USAGE OF OPTICAL NETWORKS

The first uses of optical routing are being seen with the advent of the passive, or static, Admrop Multiplexer's (ADM's) which split a fixed wavelenD@h (or band of wavelengths) from the multiplex allowing the traffic going to several nodes to share the same fibre. At first sight it appears that additional management functionality is not required for this application as the optical demands are all static point-to-point links. But care must be taken, as without the ability to essentially 'plug-in and play' the commissioning and fault isolation functions will be severely hampered by this new architecture. At a minimum this may require an automatic power balancing functions which can only be realised with a comprehensive optical management solution.

SONET or SDH provide a very comprehensive and extremely reliable form of protection for fibre and terminal failure. Fibre breaks account for a significant proportion of failures in optical systems[19] so where there are clients which do not provide this functionality then protection at the optical layer could be an attractive alternative. This could be important for legacy PDH traffic or future metro systems where additional costs in terminal equipment can not be justified. The unprotected traffic at different wavelengths is multiplexed together sending half the optical power by one route and the other half by an alternative route. At the receive end an optical switch is used to select the required route before separating the traffic into individual wavelengths. This application requires an increased management complexity with a method of *reliably* detecting a failure or degradation, but the optical switching occurs at a location where transients can not effect other traffic.

Logically this application can be evolved to consider traffic on a per wavelength basis, i.e. the power split occurs before the multiplexer and the optical switch occurs after the demultiplexer. Several nodes can now be placed on a ring with working demands between any pair of nodes passing in one direction and protection traffic travelling in the opposite direction around the ring. With the different demands operating on independent wavelengths the opportunity arises of mixing, on the same fibre, these new services with existing SDH applications, or in the future completely new applications. Management complexity is again increased, and with a single wavelength required per demand per direction it is not bandwidth efficient. In the metro market this may not be an issue, although it does not fit in with the long haul values. To improve the bandwidth efficiency (up to 50% on a ring) the idea of optically shared protection can be considered. The protection capability can again be generated via a passive optical splitter, or by a dedicated protection terminal, but now it requires switching into the shared protection wavelength at the transmitter and off the ring at the receiver.

Management complexity is considerably increased and the optical system is also no longer static; the optical protection switches cause power changes within the fibre which can have an adverse effect on other channels if no remedial action is taken. The network has thus evolved into an optical ring which provides a simple method of providing the protection capability. Provisioning will require, in addition to the points already discussed, terminals at all sites capable of receiving the signal, and possibly transmitter wavelength tunability. It is more difficult to predict when provisioning may become an option, but Nortel are investigating the possibility with a prototype wavelength router which will be described later.

4. EXTENSION FEATURES OF OPTICAL NETWORKS

By incorporating optical components into the optical layer the reliability must not be compromised, in fact, we must strive to improve the manageability of the network even though the new components do not have access to, or even knowledge of, the client layer management. It will thus be important for new optical components to be able to have access to techniques that monitor their performance and report their health to the network manager. With Optical Networks the client layer may not be SONETBDH and so the level of monitoring depend is critically on what the customer demands.

A key method of understanding the management functionality can be found in the draft ITU standard g.otn [20] which is a framework document defining a hierarchical management structure extended from the electrical SONET domain. This layered approach to management allows for the simplification and isolation of fault situations.

The control of the optical layer requires communication at all three layers. At the optical transmission and multiplex section this can be achieved by using an optical service channel (OSC) in the same way that conventional systems communicate with remote optical amplifier sites. At present no standards exist on a protocol for an OSC, although wavelengths are likely to be standardised *[21]* at 15l0nm and 1480nm in the near future. At the optical channel layer the communication mechanism must be 'tightly bound' to the wavelength which makes a tag superimposed on the channel an attractive proposition. At its most basic this tag can be a simple channel identification function although a more complex messaging system will be required to implement some types of application.

As well as the control of the individual channels their performance requires verification so that degradations can be tracked, security can be verified, and optical protection initiated in the event of a failure. This is a very complex area which is receiving a great deal of attention to find the most cost effective methods of reliably deducing and measuring the network performance. The complexity arises from the analogue nature of the WDM systems where impairments accumulate and propagate through the network.

Prototype Wavelength Router can also be used. Its key features which make up the wavelength router prototype are the application, architecture, switches, Muflmux, and the monitoring and control which are combined to provide an expandable hardware platform in which the concepts behind optical routing can be explored.

Consisting of two counter propagating unidirectional optical rings the working traffic is provisioned on the inner fibre, whilst in the event of a fault traffic can be redirected onto the outer restoration fibre where it can be transported to its destination splits the light into the separate wavelen,gh planes: at the output of the router the wavelength planes are passed through a multiplexer which combines the wavelengths onto the two output fibres. Multiplexing and demultiplexing can be performed by several technologies which are available today, the primary ones being the planar waveguide, fibre grating, and dielectric thin film interference filters. Choosing the correct technology for a given application depends on the performance, cost and upgrade requirements of the system.

The Si/SiOz planar Arrayed WaveGuide (AWG) is an exciting technology which allows a low loss, high channel count solution for separating and combining large: numbers of wavelengths. A key feature of the planar technology is that it allows the possibility of adding additional optical functionality into the planar structure, for instance optical couplers, attenuators, or Switches Between the demultiplexer and multiplexer resides the switch planes which perform the routing and monitoring functions. The switch planes are wavelength independent, and by building these planes in a modular fashion they can be added to the expansion ports from the MuxDmux, as required, to fully populate the prototype router with upto 16 wavelengths- only limited by the expansion possibilities of the Mux/Dmux. The switch plane circuit packs have been designed in such a way that the hardware acts as platform which can be used to evaluate differing switch sizes (lx2,2x2, 1x4 etc), switch technologies (mechanical and polymer, and in the future Si/Si02) and architectures, whilst still fitting into the Nortel STM16/0C48 equipment practice.

The switch plane consists of a 3x3 architecture which allows the routing or adding dropping of traffic. Monitoring is performed on the input and output of the switch plane to determine the channel ID, signal level as well as total optical power level, via tags superimposed at the transmitter. This allows the on board microprocessor controller to assess such parameters as signal level, OSNR, routing verification, and also allows control of amplitude adjusting attenuators. Fibre is also managed within the circuit pack to accommodate splices, couplers and other passive components.

5. ADVANTAGES & DISADVANTAGES OF FIBER OPTICS

5.1 Advantages of Fiber Optics

1) Quality of Connection: There is a low bit error rate with fibre optics and they are very resistant to electromagnetic interference. When an external source emits electromagnetic radiation, it creates a disruption known as EMI. An item that transmits electrical currents, such as a power line or even the sun, can disrupt or damage the performance of a standard metallic cable connection. Copper cabling is easily degraded by salt and seawater, whereas fibre optics are impervious to corrosion. This makes them an ideal choice for coastal buildings.

2) Scalability: New equipment can be readily added and put over the original fibre, making fibre optics more scalable. Wavelengths may be activated or deactivated at any time, allowing for rapid service providing and scalability as a business grows. Copper wire, on the other hand, is significantly larger and heavier than optical fibres. Typically, these fibres may be placed in place 15 to 20 years in advance of anticipated expansion demands. It's possible to insert extra fibres in case growth turns out to be hypothetical. Additional cables can be installed at a future date to allow for network growth as a different option.

3) High Security: Today's corporations place a high priority on security. Data sent using fibre optics is extremely secure. There is no way to listen in on transmissions going via fibre optics since they do not emit signals. Because every physical break in the system results in a total system failure, it is straightforward to spot breaches as soon as they occur. It is also easier to regulate and maintain fibre optic networks since you can put all of the hardware in one place. Fiber optic networks.

4) Long-Term Cost-Effectiveness: As copper's scrap value rises, theft may be a serious problem for copper wire in long-term fibre optic networks, which don't require as much overhead as copper networks. It may be more expensive to establish a fibre optic network up front, but the long-term benefits much surpass any short-term expenditures. As the use of fibre optics increases, the cost is expected to fall.

5.2 Disadvantages of Fiber Optics

It's important to weigh the benefits and drawbacks of implementing fibre optics into your network planning. Physical damage, cost, structure, and the likelihood of a "fibre fuse" are all factors to consider.

1) Physical Damage: Fiber is more fragile than metal wire since it is lighter and thinner. Because fibre optic cables are so thin, they are vulnerable to accidental severance during restorations or rewiring projects. More people may be served by fewer cables since fibre optics are capable of transmitting more data than copper networks. If one cable is severed, then a significant number of people and companies will be left without service. Some types of wildlife are attracted to the Kevlar fibre cable jackets, posing a hazard as well. Tunneling animals and rats may gnaw through the cable, while many insects find the cabling to be appetising. The transmission can be halted by anything that can be wrapped around the line. Fibers are also prone to bending, which makes it difficult to put fibres around corners. Radiation or chemical exposure can potentially harm fibre optic networks.

2) Short-Term Cost Effectiveness: Fiber installation expenses, even if they are lower in the long run, might still be expensive to accomplish. Fiber optic network installers who are knowledgeable in the use of special test equipment are typically necessary. Endpoints and connecting nexuses for fibre optics also need specialised hardware and configuration. It is also possible that a fibre optics network may require specialist equipment to assess an issue, which might lead to more expensive repairs should the cables be damaged.

3) Fiber Fuse: Fiber optic networks are vulnerable to a phenomenon known as "fibre fuse" when operating at high power. When too much light encounters a defect in the fibre, this results in a glare. Long cables can be destroyed in a short period of time by this phenomenon.

4) Unidirectional Light Propagation: Additionally, fibre cables are only able to transmit light in one way. If bidirectional communication is required for information transfer in a network, two concurrent cables must be established.

6. CONCLUSION

Several algorithms have been proposed for joint working and spare capacity planning in optical networks. These methods consider a static traffic demand and optimize network cost. Some of the gaps are left in the researches such as; Robustness of the algorithms deserves further study. The performance evaluation of the various routing algorithms for optical networks has not been covered so far. In extension features A modular design for the hardware and software is essential if the opportunities for exploiting the niche applications available in the different market sectors are to be undertaken. This modular approach will also allow the rapid deployment of new technologies, or applications, which will be crucial in the very competitive markets of today and the future.

The management of the network is of critical importance and will be the key to providing the functionality in the optical domain. It is essential to have a good understanding of the requirements of optical monitoring and control so that the security and manageability as well as the guaranteed performance at the client layer is ensured.

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