International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

An Optical Router Design for High Speed Data Centers

Utkarsh Shukla[1], Dr. Niraj Singhal[2], Dr Rajiv Srivastava[3]

[1, 2]Department of Computer Science Engineering, Shobhit University, Meerut, India

[3]IIT Kanpur, India

Abstract: ***Cloud computing facts facilities are becoming more and more famous for the provisioning of computing assets. The price and working expenses of information facilities have skyrocketed with the increase in computing capacity. Several governmental, industrial, and academic surveys imply that the power utilized by computing and communiqué devices inside a data center contributes to a sizable slice of the records center operational costs. Everything is being connected to the Cloud and Internet of Things, and network robots with huge statistics analysis are developing critical packages and offerings. The cloud community architecture is shifting closer to mega-cloud records centers (DCs) supplied by way of groups together with Amazon and Google in combination with allotted small DCs or side computers. While the conventional restrictions imposed with the aid of distance and bandwidth are being conquer through the development of superior optical interconnection, present day packages impose more complicated performance and best of provider necessities in terms of processing energy, reaction time, and facts amount.***

Keywords: Computer networks, Next generation networks, Cloud computing, Data Centers

1. Introduction

Over the previous couple of years, cloud computing offerings have come to be an increasing number of popular because of the evolving facts centers and parallel computing paradigms. The belief of a cloud is normally described as a pool of pc sources prepared to provide a computing characteristic as a application. The important IT groups, including Microsoft, Google, Amazon, and IBM, pioneered the field of cloud computing and maintain growing their offerings in records distribution and computational hosting [28]. The operation of massive geographically allotted data facilities requires massive quantity of power that debts for a large slice of the whole operational prices for cloud records facilities [6]. Gartner institution estimates electricity consumptions to account for up to 10% of the modern-day statistics middle operational charges (OPEX), and this estimate may additionally upward thrust to 50% inside the next few years [10]. However, computing primarily based power intake isn't the only power-associated part of the OPEX invoice. High power consumption generates heat and requires an accompanying cooling device that fees in a range of $2 to $5 million in step with yr for classical records centers [13]. Failure to maintain data center temperatures inside operational levels extensively decreases hardware reliability and can potentially violate the Service Level Agreement (SLA) with the clients. A predominant component (over 70%) of the heat is generated through the facts middle infrastructure [2]. Therefore, optimized infrastructure installation may additionally play a enormous position in the OPEX discount. From the electricity efficiency perspective, a cloud computing facts center may be defined as a pool of computing and verbal exchange sources organized within the way to rework the received electricity into computing or information switch paintings to meet consumer demands. The first strength saving solutions focused on making the data center hardware additives electricity green. Technologies, such as Dynamic Voltage and Frequency Scaling (DVFS), and Dynamic Power Management (DPM) [14] have been notably studied and widely deployed. Because the aforementioned strategies depend upon electricity-down and energy-off methodologies, the performance of those strategies is at best constrained. In reality, an idle server can also devour about 2/3 of the height load [3]. Because the workload of a data middle fluctuates on the weekly (and in a few instances on hourly foundation), it is a common practice to overprovision computing and communicational assets to deal with the height (or predicted maximum) load. In fact, the common load debts simplest for 30% of facts center sources [12]. This allows putting the relaxation of the 70% of the resources into a nap mode for most of the time. However, accomplishing the above requires significant coordination and power-conscious workload scheduling strategies. Typical electricity-aware scheduling answers attempt to: (a) concentrate the workload in a minimum set of the computing assets and (b) maximize the quantity of useful resource that can be put into sleep mode [8]. Most of the present day ultra-modern research on electricity efficiency has predominantly targeted on the optimization of the processing elements. However, as recorded in in advance studies, extra than 30% of the entire computing power is ate up through the communiqué hyperlinks, switching and aggregation factors. Similar to the case of processing additives, power intake of the communication material may be decreased by means of cutting down the conversation speeds and cutting operational frequency together with the enter voltage for the transceivers and switching elements [29]. However, slowing the communicational material down ought to be achieved carefully and based on the demands of user applications. Otherwise, such a procedure may result in a bottleneck, thereby limiting the overall system performance.

2. Related Work

Network-based totally cloud computing is hastily increasing as an alternative to traditional workplace-based computing. As cloud computing turns into extra large, the electricity consumption of the network and computing assets that underpin the cloud will develop. This is occurring at a time while there is growing interest being paid to the want to manipulate energy intake throughout the complete information and communications generation (ICT) quarter. While statistics middle strength use has received lots attention currently, there has been much less interest paid to the electricity consumption of the transmission and switching networks which are key to connecting users to the cloud. In this paper, **Jayant Baliga,(2010) [1]** gift an evaluation of energy consumption in cloud computing. The evaluation considers both public and personal clouds, and includes power intake in switching and transmission as well as information processing and data storage. We show that power consumption in transport and switching can be a massive percentage of general strength consumption in cloud computing. Cloud computing can enable extra energy-efficient use of computing strength, in particular when the computing tasks are of low depth or rare. However, below a few circumstances cloud computing can eat more strength than traditional computing where every person performs all computing on their very own private pc (PC). In this paper, we supplied a complete electricity intake evaluation of cloud computing. The analysis taken into consideration each public and private clouds and included energy consumption in switching and transmission in addition to statistics processing and information garage. We have evaluated the strength intake associated with 3 cloud computing offerings, specifically storage as a provider, software as a provider, and processing as a service. Any future service is in all likelihood to consist of a few combination of every of these service models. Power intake in shipping represents a considerable share of total power consumption for cloud garage offerings at medium and excessive utilization rates. For ordinary networks used to supply cloud services today, public cloud storage can consume of the order of three to 4 instances extra power than personal cloud garage because of the multiplied energy consumption in shipping. Nevertheless, personal and public cloud garage services are more electricity green than garage on neighborhood hard disk drives while files are only from time to time accessed. However, as the variety of file downloads in line with hour increases, the electricity intake in delivery grows and storage as a provider consumes extra power than garage on nearby tough disk drives. The energy savings from cloud garage are minimal. In cloud software offerings, power intake in delivery is negligibly small at very low display refresh prices. As a end result, cloud offerings are greater green than contemporary midrange PCs for simple workplace responsibilities. At slight and excessive display screen refresh fees, energy consumption in delivery turns into giant and strength financial savings over midrange PCs are decreased. The number of customers in step with server is the maximum huge determinant of the power performance of a cloud software provider. Cloud software program as a service is right for programs that require common frames fees lower than the equal of zero.1 display refresh frames according to 2nd. Significant energy savings are accomplished through the usage of lowend laptops for habitual tasks and cloud processing offerings for computationally intensive duties, in preference to a midrange or excessive-stop PC, furnished the wide variety of computationally in depth tasks is small. Energy intake in shipping with a personal cloud processing service is negligibly small. Our vast conclusion is that the power consumption of cloud computing desires to be considered as an included supply chain logistics trouble, in which processing, garage, and shipping are all considered together. Using this approach, we have shown that cloud computing can permit greater strength-green use of computing energy, in particular when the users' main computing tasks are of low intensity or rare. However, underneath some occasions, cloud computing can eat more strength than traditional computing where each person performs all computing on their very own PC. Even with power-saving techniques which include server virtualization and advanced cooling structures, cloud computing isn't constantly the greenest computing era.

Cedric F. Lam,(2010) [2] evaluated the optical verbal exchange technologies required to guide records center operations and warehouse-scale computing. To finish, fiber optics is the bloodstream for warehouse-scale computing. Remote mega datacenter operation requires both short-reach optical interconnects and long-haul optical networks. Short-reach intra datacenter interconnects with photonic integration are critical for constructing scalable datacenter clusters. To understand the gain of photonic integration, optical transceiver energy need to decrease in synchronous with the distance intake. For lengthy-haul transmission, because of the scarcity of long haul-fiber and operational cost attention, maximizing machine reach and fiber ability is of utmost importance. Exploring new spectrum inside the optical fiber and deploying more new fibers with ultra-massive powerful center areas are each crucial to cost effectively satisfy the future bandwidth demands between faraway mega datacenters.

Reducing greenhouse gas (GHG) emissions is one of the most tough studies topics in ICT due to humans's overwhelming use of digital devices. Current solutions attention in particular on efficient energy intake on the micro degree; few bear in mind big-scale strength-management strategies. The low carbon, nationwide Green Star Network in Canada makes use of network and server virtualization strategies to migrate records center services among community nodes in line with renewable electricity availability. The network deploys a "follow the solar, comply with the wind" optimization coverage as a virtual infrastructure management approach. With an boom in power intake for ICT, the GSN is a promising model for handling GHG reporting and carbon tax problems, especially for small- and medium-size ICT groups. **Mathieu Lemay and Kim-Khoa Nguyen,(2011) [3]** worked in the direction of large scale experiments on the GSN with recognize to great clinical and business offerings. The GSN protocol is also being across the world standardized.

The evolution towards grid and cloud computing as discovered for over a decennium illustrates the vital role played through (optical) networks in assisting these days's packages. In this paper, **Chris Develder, (2012) [4]** start from an outline of the difficult packages in both academic (in addition known as clinical), company (business) and nonprofessional person (patron) domains. They pose novel challenges, calling for green interworking of IT sources, for each processing and storage, as well as the community that interconnects them and offers get admission to to their users. We define the ones novel programs' necessities, together with sheer overall performance attributes (with the intention to decide the fine as perceived by using stop users of the cloud applications), in addition to the capacity to conform to converting demands (commonly called elasticity) and feasible failures (i.e., resilience). In outlining the foundational concepts that provide the building blocks for grid/cloud answers that meet the stringent software necessities we spotlight, a prominent role is played via optical networking. The pieces of the solution studied on this respect span the optical shipping layer in addition to mechanisms positioned in better layers (e.g., any cast routing, virtualization) and their interworking (e.g., through appropriate manipulate plane extensions and middleware). Based on this study, we finish by way of figuring out demanding situations and studies opportunities which could allow future-proof optical cloud structures (e.G., pushing the virtualization paradigms to optical networks). In the evolution of computing paradigms, to grids and greater lately clouds, the function of the network will become more and more essential. We have mentioned the unconventional programs that gave upward push to this evolution, and diagnosed their requirements. Even although academic packages (e-Science mainly) are pioneering inventors and adopters of latest technology and paradigms, we truely illustrated that also commercial enterprise- (cf., economic market programs striving for 0 latency and towards terabit networking) and client-orientated programs are an increasing number of stressful. We summarized a taxonomy of grid and cloud systems that provide an answer in assembly those stringent needs. The foundational standards and technology which can comprehend those systems were diagnosed. An vital role will want to be played through optical networking generation, wherein multigranular switching standards such as MLR, flexible (gridless) switching, can help to cope with the necessities for flexible bandwidth. From a routing attitude, many novel programs imply significant distribution of information (e.g., for dispensing experimental measurements or sensor statistics), which could advantage from optical multicasting. The grid/cloud paradigm also gives upward thrust to any cast routing: the stop user often does not substantially care where his procedures are strolling, for that reason introducing a degree of freedom (for this reason optimization) in deciding wherein to serve which requests (and successfully routing the worried Vol. One hundred, No. Five Proceedings of the IEEE 1163 data to/from there). Cloud computing closely is based on virtualization of IT assets, as a consequence presenting logical partitioning and probable aggregation to successfully serve time varying volumes of application requests. Moving towards Boptical clouds[by pushing the virtualization paradigms to optical networks could allow full grid/cloud convergence and as a result recognise a destiny evidence platform offering bendy, scalable IT, and community sources. Routing principles including any cast, and coordinated reservation of a (digital) network topology, collectively with IT resources name for modern allocation algorithms (in addition to monitoring gear and, e.g., autonomic control [102]–[104] to help put into effect them) and associated community design answers. From a manage and management perspective, we word that convergence of IT-orientated cloud toolkits and on-demand provisioning technology consisting of GMPLS will be a way forward to understand Boptical clouds, for which we diagnosed important demanding situations.

Cloud computing records centers have become more and more famous for the provisioning of computing resources. The cost and running prices of information centers have skyrocketed with the boom in computing potential. Several governmental, commercial, and academic surveys imply that the energy used by computing and communique devices within a statistics middle contributes to a considerable slice of the records middle operational prices. In this paper, we present a simulation surroundings for energy-conscious cloud computing records facilities. Along with the workload distribution, the simulator is designed to capture details of the power consumed through statistics center additives (servers, switches, and links) as well as packet-level communique styles in realistic setups. The simulation results obtained for 2-tier, 3-tier, and 3-tier excessive-velocity records center architectures display the effectiveness of the simulator in utilizing energy management schema, along with voltage scaling, frequency scaling, and dynamic shutdown that are carried out to the computing and networking additives. In this paper, **Dzmitry Kliazovich,(2012) [6]** supplied a simulation surroundings for strength-aware cloud computing facts centers. Green Cloud is designed to seize info of the strength fed on by means of facts center components in addition to packet-degree communication patterns between them. The simulation consequences acquired for two-tier, 3-tier, and 3-tier excessive-velocity facts middle architectures exhibit applicability and impact from the utility of different electricity management schemes like voltage scaling or dynamic shutdown carried out at the computing as well as at the networking components.

According to **Ken-ichi Kitayama, (2014) [7]** a vision of the photonic network in 2020 is supplied, which envisages a "smart photonic cloud." A clever photonic cloud is defined as a generic community platform with none bodily or logical constraint that offers flexible connectivity for machine to-machine verbal exchange along with networked high-overall performance computing or intra- and inter-records center networks. The key requirements for the community within the Big Data era encompass an ultra large potential with low strength intake, low latency, in addition to flexibility on demand to the changes within the configuration and bandwidth of the optical course. To deal with the developing call for community virtualization, novel photonic layer virtualization could be proposed, which differs from the conventional approach in terms of the number of slices and the dynamic range of the bandwidth of every slice. First, the targets and the guiding precept of the imaginative and prescient will be addressed. Next, 3 "Ss" may be supplied that constitute the key allowing technologies, namely scale-free photonics, smart photonic networking, and a artificial shipping platform. A key engine with which to realize the above three permitting technology is the photonic network processor (P-NP), that could define flexible functionality of switches and transmission structures by using software. The P-NP takes gain of the speedy progress made on virtual signal processing for coherent optical transmission systems, and it includes pools of optical frontends, digital signal processors, L1/L2 switches, which might be either electrically or optically interconnected based totally on silicon photonic technology. Finally, a multifunctional optical move-join and a piece-price-bendy optical transponder are offered as examples of P-NP packages. A photonic network imaginative and prescient for 2020 has been provided that envisions a "SPC." Photonic L2 virtualization has been mentioned, which differs from the conventional approach in terms of the huge range of slices and the large dynamic variety of the bandwidth of each slice. Three key enabling technologies, specifically scale-loose photonics, smart photonic networking, and a artificial transport platform, were proposed. The P-NP is a key engine for knowing the above 3 allowing technology which could synthesize multi-purposeful switches and transmission systems. Although there remains a lot to be studied how to realise the P-NP, silicon photonics could be one of the killer technology. The P-NP, as a key constructing block, may want to pave the way to comprehend White Box-orientated transport equipment. Finally, a multi-purposeful optical node and a bit rate-flexible OTP were provided as use instances of P-NP.

Yawei Yin,(2016) [8] discussed prospects and demanding situations of software program described elastic optical networking for grid and cloud computing environments. We will make the most the Open Flow based totally unified community control and control for each intra- and inter-datacenter networks embedded within the cloud. The intra-datacenter network is a fiber rich environment. Therefore we expect a flattened optical switching structure the use of arrayed waveguide grating routers (AWGR) with fixed spectrum grid. For the inter-datacenter community, spectral assets are more treasured among the disbursed lengthy-haul fiber connections. Therefore we count on elastic optical networks with flexible grid to obtain high spectral performance. This paper discusses the pliancy of the multi-datacenter cloud computing environment which includes each fixed-grid and flexi-grid optical networks, and introduces a unified, software program described community manipulate aircraft based on Open Flow technology. This paper discusses software program defined elastic optical networking for cloud computing. The cloud computing structures include no longer simplest datacenters and massive-scale computing structures, but additionally heterogeneous and multi-area community infrastructures that interconnect them inside and outside. In intra-datacenter networks, LIIONS utilizes the AWGR to support high-throughput and occasional-latency interconnection while main to a flattened topology with scalability. Open Flow enabled LIONS can greatly benefit from the unified control plane for the intra datacenter networks. In inter-datacenter networks, the flexible grid elastic optical networking technologies can support improved spectral efficiency and higher contains busty information traffic. The Open Flow-primarily based manage plane for EON, called Open Slice, has shown the tested performance and feasibility via field trial experiments. Overall, the Open Flow-based software program described networking offers an wise and unified manage aircraft that allows optimized usage of switching and delivery resources in intra- and inter-datacenter networks.

Advanced optical switching systems are required for connecting next technology high overall performance facts center gadget. It affords scaling of thousands of ports, and, on the same time, it achieves low conversation latency and decreased energy intake. For offering speedy optical switching, arrayed waveguide grating (AWG) routers are used within the middle of many switches. The AWG is favored because of its inherent ability to perform wavelength routing of many wavelengths parallelly. In **Vaibhav Shukla, (2018) [9]** paper, a bodily layer and community layer evaluation of AWG based totally switches is supplied and through this evaluation, a contrast is completed between the switches. The simulation effects discussed in this paper definitely display that the design of our proposed transfer is a long way higher than the currently posted layout. Moreover, our proposed switch is relatively extra cost powerful. In this paper, an AWG based totally optical packet switch structure is mentioned. The taken into consideration transfer uses WDM generation via which multiple packets can be saved in a unmarried piece of fiber. The taken into consideration architecture is as compared with the these days posted transfer layout. Through the analysis of every transfer, the subsequent have been observed.1. The strength required for the suitable operation of transfer A1 is 300 nW, even as in switch A2, the strength requirement is 9μW, so the overall performance of switch A1 is a lot higher in phrases of power requirement. Each of the switches supplied within the paper makes use of almost the identical form of components. The requirements of optical additives are high in transfer A2 compared to replace A1.3. As the fee of the optical components is just too high, a detailed price evaluation of each switch is provided inside the paper and the acquired results show that at "a=1" and "b=1," the cost of switch A1 is two,632 gadgets, whilst the fee of transfer A2 is 3,280 gadgets, so the layout of switch A1 is more value powerful. Four. The crosstalk analysis of every switch is provided in the paper; the buffer in architecture A2 is a recirculating buffer and each time the packet is circulated within the buffer, it passes through the AWG, so every time the packet passes through the AWG, an undesired factor crosstalk is delivered and this degrades the overall performance of transfer A2.In this paper, a honest evaluation is carried out between the 2 switches, and the acquired effects clearly monitor that the performance of switch A1 is far higher than that of transfer A2. So, switch A1 is the first-class to be had option for the existing information center programs.

Everything is being related to the Cloud and Internet of Things, and network robots with large facts analysis are growing critical packages and offerings. The cloud community structure is moving closer to mega-cloud information facilities (DCs) provided with the aid of businesses consisting of Amazon and Google in combination with allotted small DCs or facet computer systems. While the traditional restrictions imposed through distance and bandwidth are being triumph over by the improvement of superior optical interconnection, cutting-edge programs impose more complicated performance and pleasant of service necessities in terms of processing energy, reaction time, and data quantity. The rise in cloud performance need to be matched with the aid of enhancements in network performance. Therefore, we propose an application-brought about cloud network structure primarily based on massive-bandwidth optical interconnections. This paper addresses area/center cloud and facet/edge integration with the usage of virtual machine migration. In addition, to reduce energy consumption, an software-induced intra-DC structure is described. Using the proposed architectures and technology can comprehend strength-efficient and excessive-overall performance cloud provider. Future networks need to carry multiple new offerings to aid the smart society. Each service has one-of-a-kind characteristics and locations distinctive necessities on the community in phrases of records quantity and delay tolerance. **Naoaki Yamanaka,(2018)[10]** introduced the idea of software-triggered automated network configuration coordinated with processing capabilities and community assets. To create extra flexible and dynamic networks, the migration of VMs and capabilities ought to be possible both vertically and horizontally. First, for the smart residence and networked robot applications, we recognize centralized cloud and edge computing coordination by VM vertical migration and report on international-extensive demonstrations. Next, we describe horizontal VM migration for AD-motors. Edge computers are switched to observe the car, preserving response times beneath 10 ms at the same time as presenting triple redundancy for honest manage. We at the moment are constricting a testbed machine for an AD-car in Keio University. Next, to lessen intra-DC energy consumption, we introduce an software-precipitated go with the flow route routing approach. We successfully reveal Hadoop-based totally computerized direction routing on an electrical packet and optical circuit hybrid switching community. Our software-triggered course-routing approach makes it feasible to realize energyefficient and high-overall performance offerings for the clever society.

To guide the contemporary traits in cloud, Internet of Things, 5G, and so on., large quantities of statistics want to be processed and stored with very different performance necessities in terms of capacity, granularity, delay, and so forth. These requirements power the want for each mega-length information centers (DCs) and allotted micro DCs interconnected with excessive-speed conversation links. This special issue makes a speciality of the important thing function of optical networking in meeting those necessities via high-ability, power-efficient, and flexible connectivity, and provides recent advancements in DC architectures, network solutions, and optical technologies needed to interconnect computing and storage assets within and between DCs. We desire that the articles of this special trouble will function a beneficial useful resource for researchers who would love to get up-to-date views at the ultra-modern research efforts. **Anna Tzanakaki,(2018) [11]** would really like to thank the authors and reviewers, whose devoted efforts preserve the excessive technical standard of this journal. We also thank the JOCN Editor-in-Chief, Jane Simmons, for the continuous and precious aid she has supplied during the coaching of this special problem, and the JOCN editorial body of workers, specifically Keith Jackson, who have produced a extraordinary print extent beneath the tight schedule required for a unique problem of this type.

3. Conclusion

Future networks must bring a couple of new offerings to support the clever society. Each service has exceptional characteristics and locations extraordinary necessities at the community in phrases of statistics amount and delay tolerance. To create more bendy and dynamic networks, the migration of VMs and features have to be viable both vertically and horizontally. First, for the smart residence and networked robotic programs, we comprehend centralized cloud and facet computing coordination with the aid of VM vertical migration and report on global-huge demonstrations. and discussed a mathematical framework be presented to estimate BER performance of the optical cloud node. The power dissipation analysis will also be performed to visualize the power requirement of router.

4. Results Analysis

In the proposed design let us consider that the maximum allowed re-circulation of the packet inside the buffer is *K*, then the power received at the appropriate output port of the switch can be modeled as:

$$P_{out}(b) = bP_{in}L_{in} + \left[n_{sp}(G_B - 1)h\nu B_o \sum_{i=1}^{K} (L_B G_B)^i \right] L_{out}G_{out} + n_{sp}(G_{out} - 1)h\nu B_o L_{out} G_{out} \quad (1,2)$$

Where,

$$L_{in} = L_{TWC} L_{AWG} \quad (3)$$

$$L_B = L_F L_{SP} L_{TWC} L_{CO} L_{EDFA} L_{AWG} \quad (4)$$

$$L_{out} = L_{EDFA} L_{TWC}$$

$$L_F(m) = m\frac{vb}{R} \quad (5)$$

The loss of the switch can be partially or fully compensated.

4.1 Buffer and Output Loss Compensation

In this case buffer loss is compensated by placing optical amplifier inside the loop i.e., $L_B G_B = 1$, and the loss of the output unit is compensated by separate amplifier satisfying $L_{out} G_{out} = 1$ then

$$P_{out}(b) = bP_{in}L_{in} + Kn_{sp}(G_B - 1)h\nu B_o + n_{sp}(G_{out} - 1)h\nu B_o \quad (6)$$

In the buffer loss of each loop differ slightly due to the variation in the length of fiber, therefore gain of the EDFA also varies. Considering 'i^{th}' fiber loop, the equation 6 modifies to

For $K<m$

$$P_{out}(b) = bP_{in}L_{in} + n_{sp}(G_i - 1)h\nu B_o + (G_{out} - 1)h\nu B_o \quad 1 < i < m \quad (7)$$

For $K>m$, we can define $K=im+j$

$$P_{out}(b) = bP_{in}L_{in} + n_{sp}(G_m - 1)h\nu B_o \sum_{l=1}^{i} (L_B G_m)^l + n_{sp} (G_j - 1)h\nu B_o L_B G_j + (G_{out} - 1)h\nu B_o L_{out} G_{out} \quad (8)$$

$$P_{out}(b) = bP_{in}L_{in} + n_{sp}(G_m - 1)h\nu B_o i + n_{sp}(G_j - 1)h\nu B_o + (G_{out} - 1)h\nu B_o \quad (9)$$

4.2 Full Loss Compensation

In the second case we can compensate the loop loss i.e. $L_B G_B = 1$ and input and output losses i.e., $L_{in} L_{out} G_{out} = 1$ then

$$P_{out}(b) = bP_{in} + n_{sp}(G_B - 1)h\nu B_o \sum_{i=1}^{K} (L_B G_B)^i + n_{sp}(G_{out} - 1)h\nu B_o L_{out} G_{out} \quad (10)$$

$$P_{out}(b) = bP_{in} + K n_{sp}(G_B - 1)h\nu B_o + \frac{n_{sp}(G_{out} - 1)h\nu B_o}{L_{in}} \quad (11)$$

Similarly, equation 11 modifies to
For $K<m$

$$P_{out}(b) = bP_{in} + n_{sp}(G_i - 1)h\nu B_o + \frac{(G_{out} - 1)h\nu B_o}{L_{in}} \quad 1<i<m \quad (12)$$

For $K>m$, we can define $K=im+j$, under full loss compensation, we have

$$P_{out}(b) = bP_{in} + n_{sp}(G_m - 1)h\nu B_o i + n_{sp}(G_j - 1)h\nu B_o + \frac{(G_{out} - 1)h\nu B_o}{L_{in}} \quad (13)$$

In case of IM/DD detection noise components at the receiver are:

Shot noise: $\sigma_s^2 = 2qRPB_e$

ASE-ASE beat noise: $\sigma_{sp-sp}^2 = 2R^2 P_{sp}(2B_o - B_e)\frac{B_e}{B_0^2}$

Signal-ASE beat noise: $\sigma_{sig-sp}^2 = 4R^2 P \frac{P_{sp} B_e}{B_0}$

Shot-ASE beat noise: $\sigma_{s-sp}^2 = 2qRP_{sp}B_e$

$$\text{Thermal Noise: } \sigma_{th}^2 = \frac{4K_B T B_e}{R_L}. \quad (14)$$

In equations 13, the expressions for P and P_{sp} can be obtained from equations 7,9, 11 and 13 by breaking each equation as

$$P_{out} = P + P_{sp} = bP_{in} + P_{sp} \quad (15)$$

The total noise variance for bit b is

$$\sigma^2(b) = \sigma_s^2 + \sigma_{sp-sp}^2 + \sigma_{sp-sig}^2 + \sigma_{s-sp}^2 + \sigma_{th}^2 \quad (16)$$

The bit error rate is given by

$$BER = Q\left(\frac{RP_{out}(1) - RP_{out}(0)}{\sigma(1) + \sigma(0)}\right)$$

Where, Q(.) is error function.

Table 1: List of symbols, details and their Value

Symbols and Details	Value
Size of the switch (N)	16×16
Buffer modules (m)	16
velocity of light in fiber (v)	2.07×10^{8} m/s
Bit (b)	0, 1
Responsivity (R)	1.28 A/W
Electrical bandwidth (B_e)	10GHz
Optical bandwidth (B_o)	20GHz
Insertion Loss (TWC) (L_{TWC})	2.0 dB
Electronic Charge (q)	1.6×10^{-19} C
Insertion Loss (SOA)	1.0 dB
Insertion Loss (AWG)	3.0 dB
Insertion Loss (EDFA)	1.0 dB
Insertion Loss (Combiner) (L_{CO})	3-12 dB
Insertion Loss (Splitter) (L_{SP})	3-12 dB
Fiber Loss (L_F)	0.2 dB/km
Load Resistance (R_L)	300Ω
Temperature (T)	300K

Table 2: Power vs. BER (N=m= 16, D=2)

Buffer and Output Loss Compensation		Full Loss Compensation	
Power (µW)	BER	Power (µW)	BER
30	3.3×10^{-7}	10	1.2×10^{-7}
32	9.4×10^{-8}	11	1.6×10^{-8}
34	2.6×10^{-8}	12	2.1×10^{-9}
36	7.2×10^{-9}	13	2.5×10^{-10}
38	1.94×10^{-9}	14	3×10^{-11}
40	5.15×10^{-10}	15	3.4×10^{-12}
42	1.34×10^{-10}	16	3.7×10^{-13}
44	3.44×10^{-11}	17	3.9×10^{-14}
46	8.7×10^{-12}	18	4.1×10^{-15}
48	2.17×10^{-12}	19	4.1×10^{-16}
50	5.34×10^{-13}	20	4.0×10^{-17}

References

[1] Jayant Baliga, "Green Cloud Computing: Balancing Energy in Processing, Storage, and Transport," Proceedings of the IEEE | Vol. 99, No. 1, January 2011
[2] Cedric F. Lam, "Optical Network Technologies for Datacenter Networks (Invited Paper)," 978-1-55752-884-1/10/$26.00 ©2010 IEEE
[3] Mathieu Lemay and Kim-Khoa Nguyen, "Toward a Zero-Carbon Network: Converging Cloud Computing and Network Virtualization," Published by the IEEE Computer Society 1089-7801/12/$31.00 © 2012 IEEE IEEE INTERNET COMPUTING
[4] Chris Develder, "Optical Networks for Grid and Cloud Computing Applications," 0018-9219/$31.00 _2012 IEEE 100, No. 5, May 2012 | Proceedings of the IEEE
[5] Rod Tucker, "Energy Efficiency in Cloud Computing and Optical Networking," ECOC 2012 Tutorial
[6] Dzmitry Kliazovich, "GreenCloud: a packet-level simulator of energy-aware cloud computing data centers," Springer Science+Business Media, LLC 2010
[7] Ken-ichi Kitayama, "Photonic Network Vision 2020—Toward Smart Photonic Cloud," JOURNAL OF LIGHTWAVE TECHNOLOGY, VOL. 32, NO. 16, AUGUST 15, 2014
[8] Yawei Yin, "Software Defined Elastic Optical Networks for Cloud Computing," 2016 IEEE_Networks_Cloud_SDN_v7_Yawei
[9] Vaibhav Shukla , " Design and analysis of high speed optical routers for next generation data centre network ," Journal of Engineenng Research Vol. 6 No. (2) June 2018 pp. 122-137 [10] Naoaki Yamanaka, "Application-Triggered Automatic Distributed Cloud/Network Resource Coordination by Optically Networked Inter/Intra Data Center [Invited]," VOL. 10, NO. 7/JULY 2018/J. OPT. COMMUN. NETW. B15
[10] Anna Tzanakaki, "Special Issue on Optical Data Center Networks," VOL. 10, NO. 7/JULY 2018/J. OPT. COMMUN. NETW. ODC1
[11] Guo C, Wu H, Tan K, Shiy L, Zhang Y, Luz S (2008) DCell: a scalable and fault-tolerant network structure for data centers. In: ACM SIGCOMM, Seattle, Washington, USA

[12] Guo C, Lu G, Li D,Wu H, Zhang X, Shi Y, Tian C, Zhang Y, Lu S (2009) BCube: a high performance, server-centric network architecture for modular data centers. In: ACM SIGCOMM, Barcelona, Spain
[13] Horvath T, Abdelzaher T, Skadron K, Liu X. (2007) Dynamic voltage scaling in multitier web servers with end-to-end delay control. IEEE Trans Comput 56(4):444–458
[14] IEEE Std. 802.3ad-2000 (2000) Amendment to carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications-aggregation of multiple link segments. IEEE Press, New York.

Author Profile

Utkarsh Shukla is Assistant professor in Kanpur institute of technology and research scholar of Doctorate in philosophy in Computer science and engineering department. He publishes about 20 research paper in UGC and Scopus journals. His area of interest is image processing, cloud computing, optical communication etc.

Dr. Niraj Singhal is M.Tech. (Computer Engineering) and Ph.D. (Computer Engineering & Information Technology). He is member of several International/National bodies like Institute of Electronic and Electrical Engineers (USA), International Association of Engineers (Hong Kong), International Association of Computer Science and Information Technology (Singapore), International Engineering and Technology Institute (Hong Kong), Universal Association of Computer and Electronics Engineers (USA), Association for Computing Machinery (USA), Computer Society of India, The Institution of Engineers (India) and many more.

Dr. Rajiv Srivastava is Managing Director of Scholar tech education and senior project scientist in Indian Institute of technology Kanpur. His area of interest Fiber Optic Communication, Optical Packet Switch Architectures, Structure of LAN/MAN, Wireless Communication, Mobile communication,OFDM, IDMA, Database Replication, Image Processing, Genetic Algorithm, Spam e-mail filtering, Fuzzy Logic, Wavelet based OFDM system, Biometrics, Face Recognition and Fingerprint etc.

Paper ID: ART20203865 DOI: 10.21275/ART20203865