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REVIEW OF OPTICAL BURST SWITCHING

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ABSTRACT
This review paper is going to present an emerging technology of optical communication- Optical burst switching. Th is paper firstly compares this new emerging technology with the pre-existing switching paradigms like OCS and OP S. Then the architecture of OBS system is discussed. This review article completely explains the various mechanism s related to OBS like burst assembly, wavelength reservation, burst scheduling and contention resolution. In the end, various advantages of this exploring technology are listed.
KEYWORDS: Optical Burst switching, Burst assembly, Wavelength reservation, Burst scheduling, Burst schedulin g, Contention resolution.

INTRODUCTION
At the beginning of this new millennium of technical revolution, several new trends are observed in the field of com munications networks like increased bandwidth, more demands of Quality of Service (QoS) by the user and increase d user traffic in multimedia applications [1]. Optical fibers are found to the solution of this increasing demand. Vario us advantages of fibers include security, no interference, and lower errors in addition to enormous bandwidth. Initiall y, fibers were used for point-to-point communication where the full capacity of the fiber was not utilized. With time gap and technology advancements, in 1995, a new technology entered the market in the USA: *wavelength division m ultiplexing* (WDM) [2]. This optical multiplexing technique allows better exploration of fiber capacity by simultaneo usly transmitting multiple high-speed channels on different frequencies (wavelengths). In future telecommunication networks, traffic with different performance requirements will be merged in the same physical layer and will require new, adaptable network architectures. This has been forcing the backbone network to evolve quickly from an electr onic network to an optical network, which requires high-speed and high performance optical-switching technologies [3]. In order to utilize efficiently the amount of raw bandwidth in wavelength division multiplexing (WDM) network s, all-optical transport method must be developed to avoid electronic buffering while handling busty traffic. Several different technologies have been proposed for the transfer of data over dense wavelength division multiplexing [4]. Optical Circuit Switching (OCS) and Optical Packet Switching (OPS) are the two established switching techniques, whereas optical Burst Switching is a new one. Our whole study will be based on this new technology.

OPTICAL BURST SWITCHING (OBS)
Optical burst switching (OBS) is a new wave length division multiplexing technology that combines the advantages of both wavelength-routed (WR) networks and optical packet switching (OPS) networks [5]. Although there is no un ique definition of optical burst switching in literature, it is widely agreed that the following list describes its main ch aracteristics.

1. OBS granularity is between circuit and packet switching.
2. There is a separation between control information (header) and data. Header and data are usually carried on different channels with a strong separation in time
3. Resources are allocated without explicit two-way end-to-end signaling; instead so-called one-pass reservation is applied.
4. Bursts may have variable lengths.
5. Burst switching does not require buffering.

Differences of OBS from OCS:

a) OBS bursts immediately follow their headers without waiting for a reservation acknowledgement. While In OCS, transmission starts only after receiving end-to-end path reservation acknowledgement.
b) In burst switching, the reserved resources at each switch and output link port are held only for the duration they are needed for switching and transmission of individual bursts.
c) OBS offers better bandwidth utilization.

Differences of OBS from OPS:

a) OBS bursts are not buffered at the switches. While, packets need buffering at each intermediate node.
b) In case of OBS, small packets are aggregated into large sized bursts. This reduces guard-band impact on data channel throughput.
c) Due to reservation, OBS bursts use the path links in a time-synchronized manner. While, packets use wavelengths in an asynchronous manner.

BLOCK DIAGRAM OF OBS

In an OBS network, the basic switching entity is a burst. Burst is a variable length data packet, assembled at an ingre ss router by integrating a number of IP packets, from single or multiple hosts of same or different networks. A burst carrying the information moves from one ingress node to one egress node and switches at intermediate nodes.

The burst consists of two parts:

A. The control part of the burst carries header information and incurs control overhead.
B. The payload part is the actual data transmitted.

The functional block diagram of OBS System can be divided in two parts:

a. The Edge node:

The edge node consists of electronic router and OBS interface. There are two edge nodes in OBS network: Ingress a nd Egress edge node.

Various functions of edge node are : 1.) Electronic data buffering and processing, 2.) Burst aggregation (BA), respon sible for collecting data from legacy networks and building the burst unit, 3.) Burst Segmentation 5.) Sending the co ntrol packet and burst 6.) Ingress edge is responsible for burst assembly, routing, wavelength assignment, scheduling of burst at each node. 7.) The egress edge node is responsible for dissembling the burst and forwarding the packet to higher network layer.

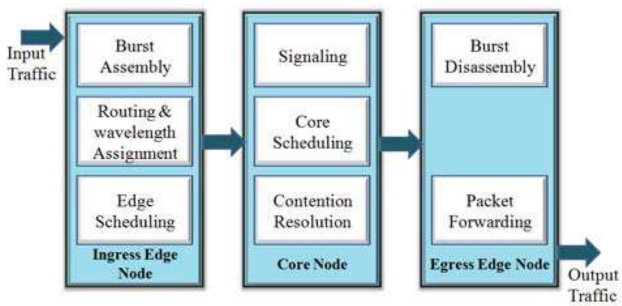

Fig 1. Block diagram of Optical Burst Switching System

b. The Core node:

Functions performed by core node: a) O-E-O conversion for header processing, b) Wavelength conversion, c) Switc hing speed fast enough, d) Eventually optical buffering, e) Processing of incoming control packets (electronically) a nd sending it to next node that lays on the routing path, f) Reservation of optical resources for transferring the burst: Just-in-Time, Horizon Reservation (HRM), Just-Enough-Time (JET), g) Fast optical switching with wavelength con version and optical buffering

ARCHITECTURAL WORKING OF OBS

The working of OBS system can be elaborated as:

1. In OBS, An ingress node assembles the internet protocol packets, which are coming from the local access networks and destined to the same egress node, into large variable sized burst. This step is called Burst Assembly. An optical burst consists of two parts, a header and a data burst. The header or label or control packet precedes the burst payload and attempts to reserve the required switching and transmission resources at each switch and output link port along the route.

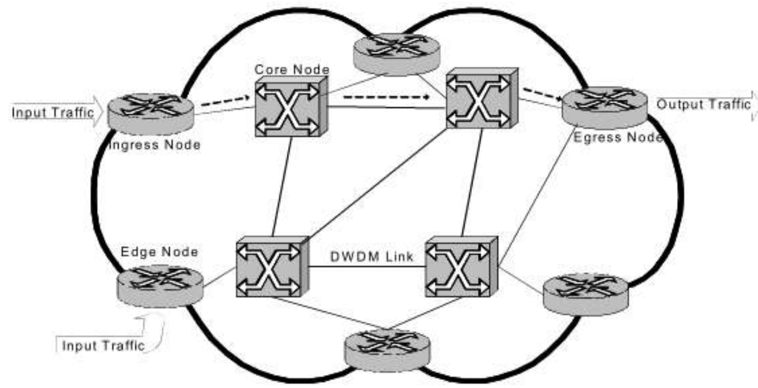

Fig 2. Architecture of OBS Network

2. Before each data burst is transmitted, a control burst is transmitted over a separate control channel. The control burst contains an information about the sender, receiver and transmission wavelength of the corresponding burst. This control burst, which is sent ahead of the data burst, undergoes Optical/Electronic/Optical (O/E/O) conversion and is processed electronically at each intermediate node, to configure the switch for the data burst that is to arrive later. This process is called as wavelength or burst reservation [6]. If more than one burst requests for the same wavelength, contention occurs. Four resolution schemes are discussed for that.
3. The offset time, which is the difference between the end time of control burst and staring time of data burst at the ingress node, is such that the data burst is switched all-optically at any intermediate node, without incurring any delay. The value of offset time is chosen to be greater than or equal to the total processing time delay encountered by the CB [6]. Hence no optical RAM or buffers are needed at any intermediate node. An intermediate node gets many control bursts and it needs to configure the switches for all the corresponding data bursts and decide channels (wavelengths) on which to schedule each data burst. This process is called as burst scheduling.

BURST ASSEMBLY SCHEMES

One of the main functions of an OBS user is to collect upper layer traffic, sort it based on destination addresses, and aggregate it into variable-size bursts. Burst assembly is a process by which all the incoming data bursts are assemble d at the edge node of OBS network. Two most popularly used burst assembly techniques are: Timer-based and thres hold-based [7]:

a) Timer based technique: In a timer-based burst-assembly approach, a burst is created and sent into the optical network when the time-out event is triggered. Timer based systems are suitable for time-constrained traffic for instance real-time applications because the upper bound of burst assembly delay is limited.

b) Threshold-based technique: In a threshold-based approach, a limit is placed on the number of packets contained in each burst. A burst is created and sent into the OBS network when the total size of the packets in the queue reaches a threshold value. This does not provide any guarantee on the assembly delay that packets will experience. Threshold systems are used for time-insensitive applications like file transmission, to reduce the overhead of control packets, increase OBS transmission efficiency.

WAVELENGTH RESERVATION FOR BURSTS

It is the process of reservation and release of bandwidth. In this process we define how much and when the bandwidt h is to be allocated to each burst. The reservation process in OBS is taken from ATM block transfer (ABT). There ar e basically two schemes:

A. ABT with immediate transmission

In this, an output wavelength is reserved for a payload immediately after the arrival of corresponding control packet; if a wavelength can't be reserved at that time, the set-up message is rejected and corresponding data burst is dropped . This scheme can be further implemented in two ways depending on the bandwidth reservation, offset time and cont rol management.

(a) Tell-And-Go (TAG) [8]

- An immediate reservation scheme.

- The control packet is transmitted on a control channel, then after zero or negligible offset, a payload is transmitted over the data channel.
- The control packet is transmitted and processed at each node while fiber delay line (FDL) buffers the payload.
- If the wavelength reservation is successful then payload is transmitted along control, otherwise negative acknowledgment is sent to the receiver. Next control is sent only after the successful transmission of payload.
- Drawbacks: a) Need of optical buffer. Moreover, FDL can hold the data only for a fixed duration and can't accommodate bursts of varying size.
  b) Loss of control packet to release reserved resources result in wastage of bandwidth.

(b) Just-in-Time (JIT) [9]:

- An immediate reservation scheme. Because nodes reserve the resources as soon as the control packet is processed.
- Upon the arrival of a control packet to a core OBS node, a wavelength channel is immediately reserved if available. If no wavelength is available the request is blocked and the corresponding data burst is dropped. When the wavelength is successfully reserved, it remains reserved until the data burst transmission has finished. The only information that needs to be kept in the network nodes is whether the wavelength is currently reserved or not. The control packet is not aware of the burst length and reserves the relevant link bandwidth (if available) for the entire burst as soon as it arrives at the switch.
- The difference between JIT and TAG is that in JIT, the buffering of the payload at each node is eliminated by inserting a time (equal to offset time) slot between the control packet and the payload.
- Drawbacks: a) Since the bandwidth is reserved immediately after processing the control packet, the wavelength will be idle from the time the reservation is made till the first bit of payload arrives at the node. This happens due to offset time inserted.
  b) An in-band terminator is placed at the end of each data burst, which is used by each node to release th e reserved wavelength after transmitting the payload.

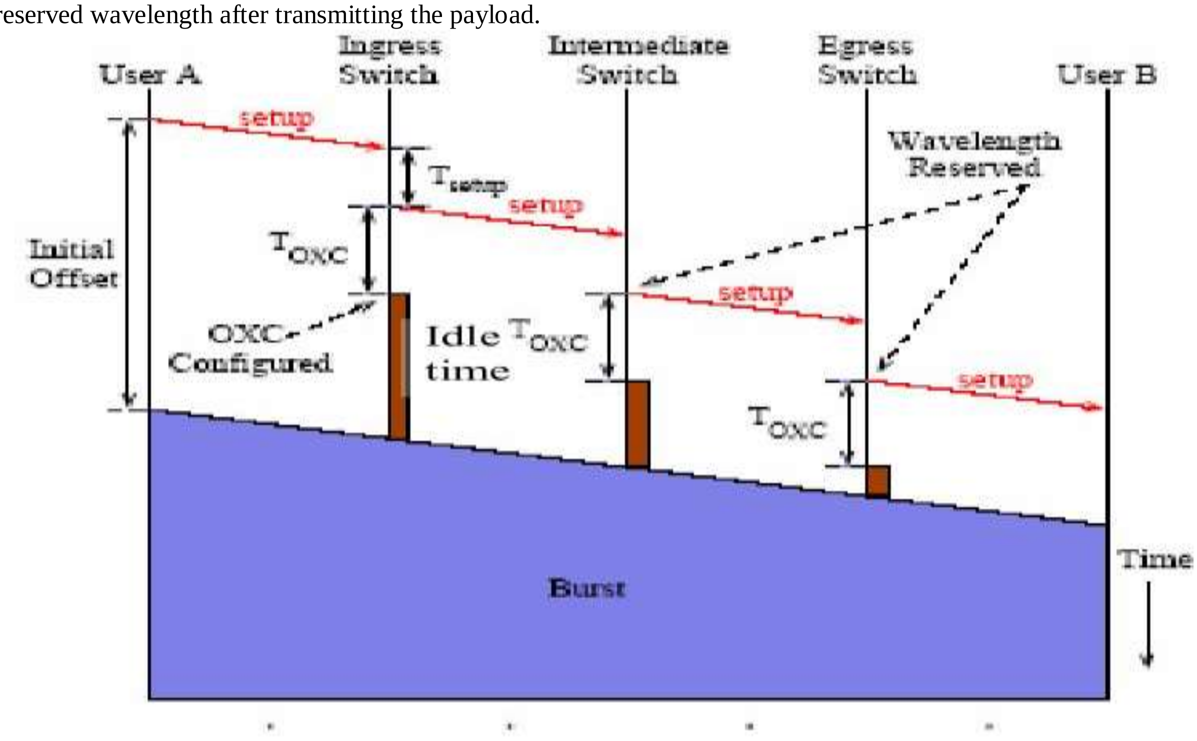

Fig 3. Just-In-Time (JIT) Reservation

B. ABT with delayed transmission

Here, the control packet and the payload are separated in time by an offset value in order to accommodate the proces sing of the control packet. An output wavelength is reserved for a data burst just before the arrival of first bit of data burst. If upon arrival of set-up message, it is determined that no wavelength can be reserved at appropriate time, then the set-up message can be rejected and the data burst is dropped. This scheme is achieved in following scheme:

Just-Enough-Time (JET) [10]:

- A delayed reservation scheme.
- This scheme reserves resources exactly for the transmission time of the data burst. In JET, when a control packet arrives at a core node, a wavelength channel scheduling algorithm is invoked to find a suitable wavelength channel on the outgoing link for the corresponding DB. The wavelength channel is reserved for duration equal to the burst length starting from the arrival time of the DB. The information required by the scheduler such as the data burst arrival time and its duration are obtained from the control burst.
- In JET, the size of data burst is decided before the control packet is transmitted by the source. The offset between control packet and payload is also calculated based on the hop count between the source and destination.

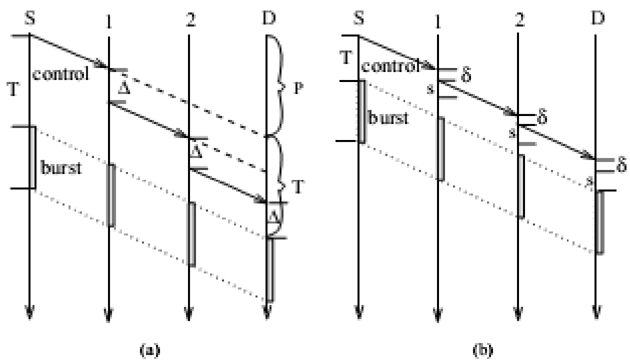

Fig 4. Just-Enough-Time (JET) Reservation

- Advantage over TAG and JIT: a) The reservation of wavelength is made from the time when first bit of payload reaches the node till the last bit is transmitted to output port. This eliminates the wavelength idle time. b) Since wavelength is reserved for a fixed duration, there is no need for explicit release of reserved resources along the path. Thus, no bandwidth wastage implies higher channel utilization. Its performance is much better than other two in terms of burst loss probability.
- Drawback: Involves complex scheduling or void filling algorithm. Hence, more complex than JET and TAG.

BURST SCHEDULING ALGORITHMS

Burst scheduling is the mechanism of placement of a particular burst on the wavelength channel. There are various a lgorithms for scheduling of burst:

1. First Fit Unscheduled channel (FFUC) [11]: At or after the arrival time of payload, FFUC algorithm searches all the unused channels in a fixed order and assigns the first unused channel to the incoming burst. e.g. In fig, when a burst arrives, the algorithm searches for all the unused available channels. Channel 1 and 2 satisfy the requirements. FFUC selects the channel 1 as it is first available.
2. Latest Available Unscheduled Channel (LAUC) [12]: LAUC selects that unscheduled data channel in which the void created after the placement of the data burst is of minimum size. e.g. Channel 1 and 2 are available channels. On placement of data burst in channel 1 and 2 create void (t_b-t_1) and (t_b-t_2) respectively. Since, (t_b-t_1) □ (t_b-t_2), thus data burst is placed on channel 2.
3. First Fit Unscheduled Channel with Void filling (FFUC-VF) [12]: FFUC-VF search for all possible voids in the network and schedule the burst in the first available void. e.g. voids are present in channel 3,4 and 5. FFUC-VF selects channel 3 as it is providing first void.
4. Latest Available Unscheduled Channel with Void filling (LAUC-VF) [12]: LAUC-VF firstly searches all the data channels to find the available voids and then places the burst on that void that create minimum sized void after placement of burst. The void is checked between start-time of newly arrived data burst and start time of already scheduled data burst. e.g. in figure, channel 3, 4, 5 and 6 are providing the voids. But LAUC-VF schedule the burst in void 4 as the void created is smallest in this case.

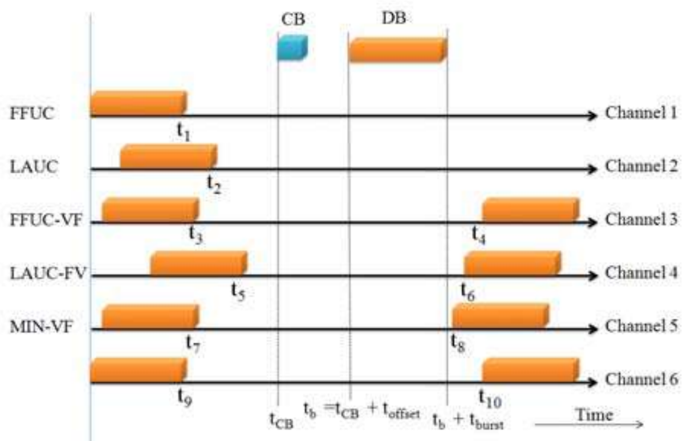

Fig 5. Various burst scheduling Algorithms [14]

5. Minimum End Void (Min-EV) [13]: Min-EV is a variation of LAUC-VF that works in similar fashion. The only difference lies in void calculation. The advantages and disadvantages are same as in the case of LAUC-VF. The void is calculated between the end time of newly arrival data burst and start time of already scheduled data burst.

CONTENTION RESOLUTION TECHNIQUES

Contention is a problem in OBS that occurs when more than one data burst tries to reserve the same wavelength cha nnel on an outgoing link. In electronic systems, this problem is resolved by buffering one of the contending packets. While in OBS, there are four basic contention resolution techniques that can be used individually or in combination:

1. Optical Buffering [10]*:* Fiber Delay Line (FDL) is presently the only way to achieve the buffering. Optical buffer is usually composed of fiber delay lines (FDLs). While the contending bursts are transmitted in FDL with a fixed length the transmission delay caused by light wave transmission delay in optical fiber can be used as the optical buffering time. Once an optical burst has entered into the optical fibre, it must come out from the other end after a certain time. Major drawbacks: a) FDLs are bulky and require over a kilometre fiber to delay a single packet for 5s. b) FDL provides only a fixed delay. c) Data leaves the FDL in same order in which they entered.
2. Wavelength Conversion [15]*:* Process of converting a wavelength on an incoming channel to another wavelength on an outgoing channel. This scheme increases the wavelength re-usability by shifting the contending data bursts wavelength to another wavelength on designated output link [15].

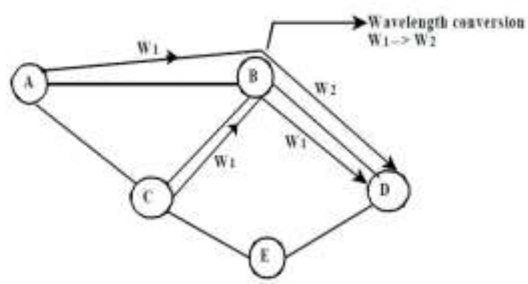

Fig 6. Wavelength Conversion [10]

3. Deflection Routing [16]: Best approach in WDM networks where buffering and wavelength conversion are not possible. In this, the contending burst is routed to an output port other than the desired one and then is directed to the destination through alternative route.

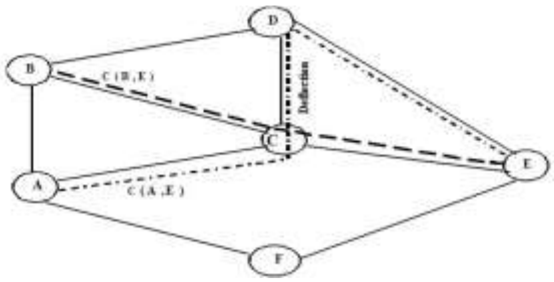

Fig 7. Deflection Routing [10]

4. Burst segmentation*:* In burst segmentation [17], the burst is divided into basic transport units called segments. When contention occurs, only those segments of another burst will be dropped. If switching time is not negligible, then additional segments may be lost when the output port is switched from one burst to another. There are two approaches for dropping burst segments when contention occurs between bursts. The first approach, tail dropping, is to drop the tail of the original burst, and the second approach, head dropping, is to drop the head of the contending burst [17].

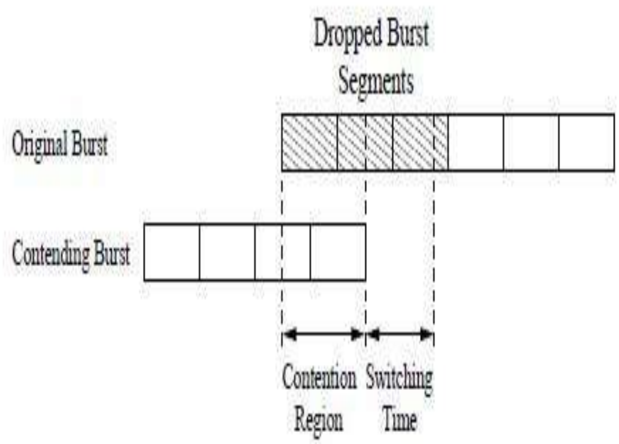

Fig 8. Burst Segmentation [10]

Table 1. Comparison table of different contention resolution schemes [17]

Contention Resolution	**Advantages**	**Disadvantages**
FDL buffering	Simple	Increasing end-to-end delay
Wavelength Conversion	The most efficient solution	Immature and expensive
Deflection Routing	No extra hardware is requir ed	Out of order arrival
Burst segmentation	Lower packet loss ratio	Complicated control handling requirement

ADVANTAGES OF OBS

There are various advantages of this burst switching over the previous existing techniques:

1. There is no need to terminate the optical wavelength channel pre-maturely (earlier to final destination) just for con nections add/drop purpose.

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2. OBS system offers statistical traffic multiplexing, routing and switching at the optical layer at core network layers , which allows fewer core IP/MPLS router ports. Thus, cost of burst routing decreases. Moreover, bandwidth can be much better utilized in OBS.
3. The number of regenerators required for optical-to-electrical or vice-versa conversion is very small. These are onl y required for signaling traffic at each node. This reduces the cost incurred in OEO conversions.
4. It conceptually aims at the benefits of packet switching but without the need of optical-to-electrical-to-optical con version at intermediate switching nodes [18]. This thing is possible just because of the fact that we can vary the size of burst by our choice. As in WR networks, there is no need for buffering and electronic processing for data at inter mediate nodes. At the same time, OBS increases the network utilization by reserving the optical channel for a limite d time period.

DISADVANTAGES OF OBS

An OBS network edge router is likely to be more complex than an OPS network edge router, due to possible need fo r a burst assembly/aggregation and a sorting stage. Consequently, energy consumption at the edge of an OBS networ k may be higher than in an OPS network [19].

CONCLUSION

This can be concluded from this review article that Optical Burst ewitching is a very promising communication tech niques in fiber communication. It is still under research and is going to acquire the full communiucation market in fe w years.

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