Global Information Assurance Certification Paper

Securing Optical Networks

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What is an all-optical or photonic network?

The quest for greater bandwidth has led to the birth of the All-Optical Network. An all-optical or photonic network has the function of a traditional communications network but is run with various optical components. Optical transmitters and receivers or IR (infrared) transmissions take the place of conventional fiber cables. Optical signals are transmitted through the air and are converted to electrical signals and back to transmit data and the diagnose network integrity.

Why would you want to have an optical network? There are many benefits as: increased bandwidth since photons move faster than electricity, up to and beyond gigabit speeds, there are shorter transmission delays making data sharing and real time calculations quicker, the thousands of signals can be compressed into a single beam by using frequency division multiplexing, and a single strand of fiber, if needed can carry several wavelengths embedded into one beam by means of wavelength division multiplexing, which makes the network flexible. Several streams of data can be contained in one beam. Efficiency and speed also help give this network less packet loss.

There are two types of commercially offered all-optical network functions: wavelength division multiplexing and time division multiplexing. Wavelength division multiplexing currently has more of a commercial appeal though time division multiplexing has great speed.

Types of All-Optical Network Functions

Function #1:
WDM – Wavelength Division Multiplexing
Multiple channels of network traffic are separated it's own wavelength.

Function #2
TDM – Time Division Multiplexing
Multiple channels of network traffic are separated into its own time slot. It gives the network bandwidth on demand.

Hardware Components

The following are various components that make up an optical network. The components can vary per network design, purpose and technological innovation.

Cabling Fiber – single or multi mode
A cable made out of shielded glass and used to transport signals.
Optical receivers
It is hardware that receives the optical signal. It can either be a relay or at a customer site.
Optical transmitters
It is hardware that transmits the optical signal.
Spatial switch
Lets a signal pass through or drop out and can switch signals between fibers.
Optical Amplifier
Acts as a signal booster or repeater to increase signal strength.
Multiplexer
Combines signal from many fibers into one fiber.
Demultiplexer
Separates many signals from one fiber into one signal per fiber (many fibers).
Splitter
Split one signal into more than one signal.
Combiner
Combines many signals in to one single signal.

Methods of Attacks

Physical security, data integrity and data availability are important to any network. An attacker can use different methods of breaking into a network. Below are a few methods and examples of attacks.

Data Delay

All-optical networks are immune to this type of attack where the attacker would intercept and either divert or delay data due to the lack of optical memory.

Denial of Service & QoS Degradation

Denial of Service attacks are when an attacker affects the network availability.
Quality of Service attacks are when an attacker threatens network integrity.
Both of these attacks are a type of service disruption of which optical networks are prone. Tightening up the network topology and cryptography are two methods that can be used against those attacks.

Traffic Analysis & Eavesdropping

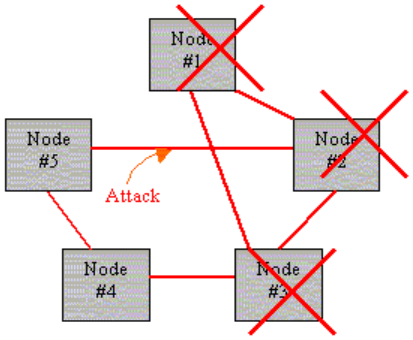
Traffic analysis is when an attacker collects communication patterns, not content from a network.
Eavesdropping is when the content of the traffic is collected and scanned by the attacker.

Spoofing

Spoofing attacks are not feasible in an all-optical network if encryption methods are used. Pretending to be a trusted entity in this case would be difficult if not impossible without intimate knowledge of the network.

In Band Jamming

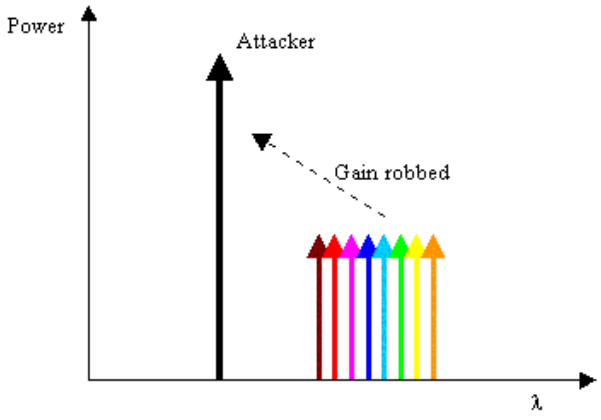
In band jamming is a type of denial of service attack, where the attacker inserts a signal into your in order to disrupt the receivers ability to process the signal correctly. If an attacker were to use a single high powered signal on a specific optical link. It could damage that optical link. If redundancy of the network were employed, or blocking or filtering of that signal were used this would not be an issue.



picture from Kaius Nevaste ,"Optical Network Security"

Out-of-Jamming

Out of band Jamming is also a type of denial of service attack, where the attacker diminishes the transmission or flow of a signal by exploiting components with crosstalk leaks or cross modulation effects. If an attacker were to introduce another signal at a different wavelength than the network the optical amplifier will accept the signal unless it were filtered out. Since the Optical amplifier cannot distinguish between a legitimate signal and an attack signal the attack can be successful.
Those photons provided by the attacker can rob the gain available to the signal and allow it to propagate to other nodes on the network.



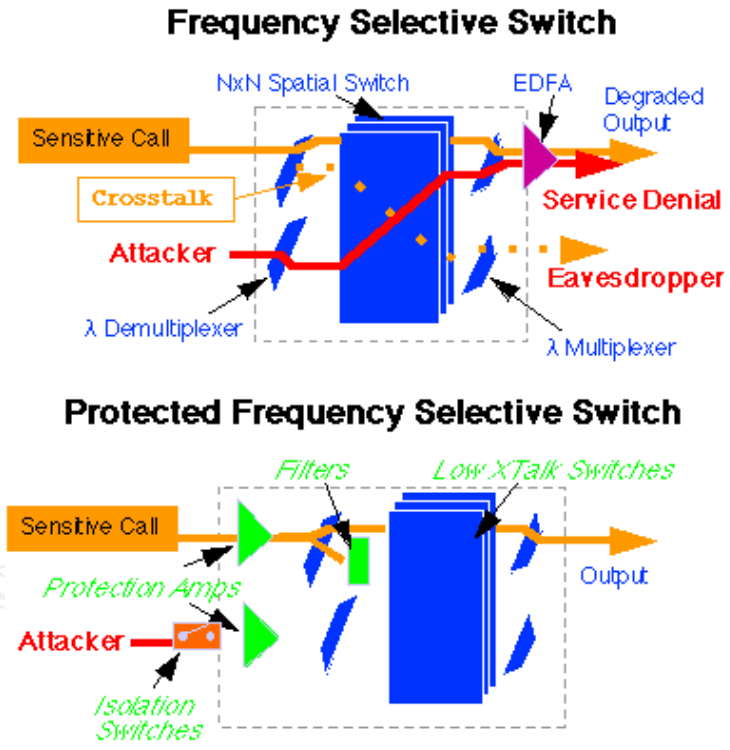
picture from Kaius Nevaste ,"Optical Network Security"

Unauthorized Observation

Unauthorized observation is a form of eavesdropping where the attacker listens to the crosstalk leaking from an adjacent signal through a shared resource. The attacker can gain information helpful to breach the network. Demultiplexer can exhibit cross talk at 0.03% - 1.0% making this a low level threat.

Examples of other hardware and vulnerabilities

EDFA, Erbium Doped Fiber Amplifiers can be subject to jamming. They are an optical amplifier. Modulation in the signals going over the network leaves it vulnerable to attack.
Frequency selective switches are susceptible to eavesdropping. An attacker can introduce a signal into your in order to disrupt the receivers ability to process the signal correctly. See diagram below for an example of this.



picture from MIT Library "Advanced Network Group Secure All-Optical Networking"

Encryption

Since some forms of encryption can cause a bottleneck in the all-optical network because they are complex and take up a large amount of time to complete. The method of dual transmission encryption was developed to speed up the process and add a method of security to the network. This method of encryption reminds me of public key encryption in the traditional network setting.

Two data streams are sent over a single optical carrier link. They are combined to make a single signal that is modified from the original signal and embedded within the optical carrier phase. By using differential phase shift keying (DPSK) and frequency shift keying (FSK) together this form of encryption is accomplished.

An optical data encryptor encrypts inputted data signal, then frequency to frequency coding is done be fore sending the data, by using the differential frequency shift Keying (DFSK) logic signals. On the receiving end there is a frequency modulation unit that processes the DFSK logic signals and a pair of key bits to translate the signal. This operation encrypts the optical transmission.

Conclusion

In this paper we described an all-optical network, explained the hardware components and depicted a few attacks and vulnerabilities of this high-speed network. Though this type of network is still evolving and there were no clear ways to avoid an attack. Like a traditional network the ideology of prevent, protect, react applies to both this and a traditional network. Since this is a high-speed network attacks need to be detected sooner and prevention has to be built in to the network and architecture.

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