optical components in the network. The optical components can be grouped logically as network elements for the purposes of network management. One or more network elements can be established at each optical component site in the network depending upon the desired functionality in the network and management system.

[0033] The NMS **18** can be connected directly or indirectly to network elements located either in the nodes **12** or remotely from the nodes **12**. For example, the NMS **18** may be directly connected to network elements serving as a node **12** via a wide area or data communication network ("WAN" or "DCN", shown in broken lines in **FIG. 1**). Indirect connections to network elements that are remote to the DCN can be provided through network elements with direct connections. Mixed data or dedicated supervisory channels can be used to provide connections between the network elements. The supervisory channels can be transmitted within and/or outside the signal wavelength band on the same medium or a different medium depending upon the system requirements.

[0034] The optical transmitters **20** transmit information as optical signals via one or more signal channels λ_{si} through the transmission media **16** to optical receivers **22** located in other processing nodes **12**. The transmitters **20** used in the system **10** generally includes an optical source that provides optical power in the form of electromagnetic waves at one or more optical wavelengths. The optical source can include various coherent narrow or broad band sources, such as DFB and DBR lasers, sliced spectrum sources and fiber and external cavity lasers, as well as suitable incoherent optical sources, e.g., LED, as appropriate. The sources can have a fixed output wavelength or the wavelength can be tunable using various feedback and control techniques, such as temperature, current, and gratings or other components or means for varying the resonance cavity of the laser or output of the source.

[0035] Information can be imparted to the electromagnetic wave to produce an optical signal carrier either by directly modulating the optical source or by externally modulating the electromagnetic wave emitted by the source. Alternatively, the information can be imparted to an electrical carrier that can be upconverted, or frequency shifted, to an optical signal wavelength λ_{si}. Electro-optic (e.g., $LiNbO_3$), electro-absorption, other types of modulators and upconverters can be used in the transmitters **20**.

[0036] In addition, the information can be imparted using various modulation formats and protocols. For example, various amplitude modulation schemes, such as non-return to zero (NRZ), differential encoding, and return to zero (RZ) using various soliton, chirped, and pulse technologies. Various frequency, phase, and polarization modulation techniques also can be employed separately or in combination. One or more transmission protocols, such as SONET/SDH, IP, ATM, Digital Wrapper, GMPLS, Fiber Channel, Ethernet, etc. can be used depending upon the specific network application. It will be appreciated that the transmitters **20** and receivers **22** can use one or more modulation formats and transmission protocols within the network.

[0037] The optical receiver **22** used in the present invention can include various detection techniques, such as coherent detection, optical filtering and direct detection, and combinations thereof. The receivers **22** can be deployed in modules that have incorporated wavelength selective filters to filter a specific channel from a WDM signal or channel filtering can be performed outside of the receiver module. It will be appreciated that the detection techniques employed in the receiver **22** will depend, in part, on the modulation format and transmission protocols used in the transmitter **20**.

[0038] Generally speaking, N transmitters **20** can be used to transmit M different signal wavelengths to J different receivers **22**. Also, tunable transmitters **20** and receivers **22** can be employed in the optical nodes **12** in a network, such as in **FIG. 1**. Tunable transmitters **20** and receivers **22** allow system operators and network architects to change the signal wavelengths being transmitted and received in the system **10** to meet their network requirements.

[0039] In addition, the transmitters **20** and receivers **22** can include various components to perform other signal processing, such as reshaping, retiming, error correction, differential encoding, protocol processing, etc. For example, receivers **22** can be connected to the transmitters **20** in back to back configuration as a transponder or regenerator, as shown in **FIG. 2**. The regenerator can be deployed as a 1R, 2R, or 3R regenerator, depending upon whether it serves as a repeater (repeat), a remodulator (reshape & repeat), or a full regenerator (reshape, retime, repeat).

[0040] In a WDM system, the transmitters **20** and receivers **22** can be operated in a uniform manner or the transmission and reception characteristics of the signal channels can be tailored individually and/or in groups. For example, pre-emphasis, optical and/or electrical pre- and post-dispersion and distortion compensation can be performed on each channel or groups of channels.

[0041] In **FIG. 2**, it will be appreciated that the transmitters **20** and receivers **22** can be used in WDM and single channel systems, as well as to provide short, intermediate, and/or long reach optical interfaces between other network equipment and systems. For example, transmitters **20** and receivers **22** deployed in a WDM system can be included on a module that includes standardized interface receivers and transmitters, respectively, to provide communication with interfacial devices **30**, as well as other transmission and processing systems.

[0042] The optical amplifiers **24** can be deployed periodically along optical links **15** to overcome attenuation that occurs in a span of transmission media **16**. In addition, optical amplifiers **24** can be provided proximate to other optical components, for example, at the node **12** as booster and/or pre-amplifiers to provide gain to overcome component losses. The optical amplifiers **24** can include doped (e.g. Er, other rare earth elements, etc.) and non-linear interaction (e.g., Raman, Brillouin, etc.) fiber amplifiers that can be pumped locally or remotely with optical energy in various configurations.

[0043] For example, optical fiber amplifier **24** generally include an amplifying fiber supplied with power in the form of optical, or "pump", energy from one or more pump sources. The amplifying fiber can have the same or different transmission and amplification characteristics than the transmission fiber. Thus, the amplifying fiber can serve multiple purposes in the optical system, such as performing dispersion compensation, as well as different levels of amplification of the signal wavelengths λ_i. The pump source **36** can