include one or more narrow band or broad band optical sources, each providing optical power in one or more pump wavelength ranges designated by center pump wavelengths λ_{pi} and including one or more spatial and/or longitudinal modes. Pump energy can be supplied to the amplifying fiber, either counter-propagating and/or co-propagating with respect to the propagation of the signal wavelengths λ_i.

[0044] Other types of optical amplifiers, such as semiconductor amplifiers, can be used in lieu of, or in combination with the fiber amplifiers. The optical amplifiers **24** can include one or more serial and/or parallel stages that provide localized gain at discrete sites in the network and/or gain that is distributed along the transmission media **16**. Different amplifier types can be included in each stage and additional stages to perform one or more other functions. For example, optical regeneration, dispersion compensation, isolation, filtering, add/drop, switching, etc. can be included at a site along with the optical amplifier **24**.

[0045] Various types of optical switching devices, both optical switches **26** and OADMs **28**, can be integrated into the nodes **12** and the all-optical networking functionality of the devices can be used to establish distance independent networks. The switching devices allow for integrated optical transport switching, adding, dropping, and/or termination of signal channels from multiple paths **14** entirely in the optical domain. The switching device eliminate the need for receivers **22** and transmitters **20** to perform electrical conversions, as required when using interfacial devices **30**, merely to pass the information through intermediate nodes $\mathbf{12}_i$. As such, signal channels can optically pass through intermediate nodes $\mathbf{12}_i$ between the origin nodes $\mathbf{12}_o$ and destination nodes $\mathbf{12}_d$ channels, bypassing the need for transmitters **20** and receivers **22** at the intermediate nodes $\mathbf{12}_i$. In this manner, the switching devices provide transparency through the node that allows all-optical express connections to be established between non-adjacent origin and destination nodes in a network.

[0046] The signal channels optically passing through the switching devices can be distributed from a common path to multiple diverse paths, as well as combined from multiple diverse paths onto a common path. It will be appreciated that signal channels that are switched onto a common path by the switching devices from different paths can have different properties, such as optical signal to noise ratio. Conversely, signal channels entering the switching devices from a common path and exiting the devices via different paths may require that the signal channels exit with different properties, such as power level. As such, signal channels may have different span loss/gain requirements or tolerances within the link **15**.

[0047] The optical switches **26** and OADMs **28** can be configured to process individual signal channels or signal channel groups including one or more signal channels. The switching devices also can include various wavelength selective or non-selective switch elements, combiners **32**, and distributors **34**. The transmitters **20** and receivers **22** can be configured to transmit and receive signal channels dynamically through the switch elements or in a dedicated manner exclusive of the switch elements using various combiners **32** and distributors **34**. The OADMs can include wavelength reusable and non-reusable configurations. Similarly, the switching devices can be configured to provide multi-cast capability, as well as signal channel terminations.

[0048] The switching devices can include various configurations of optical combiners **32** and distributors **34**, such as multiplexers, demultiplexers, splitters, and couplers described below, in combination with various switch elements configured to pass or block the signals destined for the various other nodes **12** in a selective manner. The switching of the signals can be performed at varying granularities, such as line, group, and channel switching, depending upon the degree of control desired in the system **10**.

[0049] The switch element can include wavelength selective or non-selective on/off gate switch elements, as well as variable optical attenuators having suitable extinction ratios. The switch elements can include single and/or multiple path elements that use various techniques, such as polarization control, interferometry, holography, etc. to perform the switching and/or variable attenuation function. The switching devices can be configured to perform various other functions, such as filtering, power equalization, dispersion compensation, telemetry, channel identification, etc., in the system **10**.

[0050] Various two and three dimensional non-selective switch elements can be used in present invention, such as mechanical line, micro-mirror and other micro-electro-mechanical systems ("MEMS"), liquid crystal, holographic, bubble, magneto-optic, thermo-optic, acousto-optic, electro-optic ($LiNbO_3$), semiconductor, erbium doped fiber, etc. Alternatively, the switch elements can employ fixed and tunable wavelength selective multi-port devices and filters, such as those described below. Exemplary switching devices are described in PCT Application No. PCT/US00/23051, which is incorporated herein by reference.

[0051] The interfacial devices **30** may include, for example, protocol and bit rate independent devices, such as optical switches and/or protocol and bit rate dependent electrical switch devices, such as IP routers, ATM switches, SONET add/drop multiplexers, etc. The interfacial devices **30** can be configured to receive, convert, and provide information in one or more various protocols, encoding schemes, and bit rates to one or more transmitters **20**, and perform the converse function for the receivers **22**. The interfacial devices **30** also can be used as an input/output cross-connect switch or automated patch panel and to provide protection switching in various nodes **12** depending upon the configuration. The interfacial devices **30** can be electrically connected to the transmitters **20** and receivers **22** or optically connected using standard interface and/or WDM transmitters and receivers, as previously described.

[0052] Optical combiners **32** can be provided to combine optical signals from multiple paths into a WDM signal on a common path, e.g. fiber, such as from multiple transmitters **20** or in optical switching devices. Likewise, optical distributors **34** can be provided to distribute one or more optical signals from a common path to a plurality of different optical paths, such as to multiple receivers **22** and/or optical switching devices.

[0053] The optical combiners **32** and distributors **34** can include wavelength selective and non-selective ("passive") fiber, planar, and free space devices, as well as polarization sensitive devices. For example, one or more multi-port devices, such as passive, WDM, and polarization couplers/splitters having various coupling/splitting ratios, circulators, dichroic devices, prisms, diffraction gratings, arrayed