WAVELENGTH NEGOTIATION METHOD AND APPARATUS OF MULTI-WAVELENGTH PASSIVE OPTICAL NETWORK, AND MULTI-WAVELENGTH PASSIVE OPTICAL NETWORK SYSTEM

TECHNICAL FIELD

[0001] This application mainly relates to optical communications technologies, and in particular, to a wavelength negotiation method and apparatus of a multi-wavelength passive optical network (Passive Optical Network, PON), and a multi-wavelength passive optical network system.

BACKGROUND

[0002] A passive optical network (PON) technology is currently a main broadband access technology. A conventional PON system is a point-to-multipoint network system based on a time division multiplexing (Time Division Multiplexing, TDM) mechanism. Referring to FIG. 1, the PON system generally includes an optical line terminal (Optical Line Terminal, OLT) located on a central office side, multiple optical network units (Optical Network Unit, ONU) located on a user side, and an optical ~~distributing~~ distribution network (Optical ~~Distributing~~Distribution Network, ODN) between the OLT and the ONUs. The ODN is used to distribute or multiplex data signals between the OLT and the ONUs so that the multiple ONUs can share an optical transmission path. In the PON system based on the TDM mechanism, a direction from the OLT to the ONUs is called downstream, the OLT broadcasts a downstream data stream to all the ONUs in a TDM manner, and each ONU receives only the data that carries an identifier of the ONU; a direction from the ONUs to the OLT is called upstream. Because all the ONUs share the optical transmission path, in order to prevent a conflict of upstream data between

[0035] In the multi-wavelength PON system 100, a communication link between the OLT 110 and the multiple ONUs 120 may include multiple upstream wavelength channels and multiple downstream wavelength channels. In a downstream direction, the multiple downstream wavelength channels also share the optical transmission medium of the ODN in a wavelength division multiplexing (WDM) manner, each ONU 120 may work on one of the downstream wavelength channels of the multi-wavelength PON system 100, and each downstream wavelength channel may carry downstream services of one or more ONUs 120; the ONUs 120 that work on a same downstream wavelength channel may share the downstream wavelength channel in a Time Division Multiple Access (TDMA) manner. In an upstream direction, the multiple upstream wavelength channels share the optical transmission medium of the ODN 130 in a WDM manner, each ONU 120 may work on one of the upstream wavelength channels of the multi-wavelength PON system 100, and each upstream wavelength channel may carry upstream services of one or more ONUs 120; the ONUs 120 that work on a same upstream wavelength channel may share the upstream wavelength channel in a Time Division Multiple Access (TDMA) manner.

[0036] In this embodiment, as shown in FIG. 2, a description is given by using an example in which the multi-wavelength PON system 100 has four upstream wavelength channels and downstream wavelength channels. It should be understood that in practical application, the number of the upstream and downstream wavelength channels of the multi-wavelength PON system 100 may also be determined according to network requirements. For ease of description, in this embodiment, the four upstream wavelength channels of the multi-wavelength PON system 100 are separately named an upstream wavelength channel 1 (which uses a first upstream wavelength λ u1), an upstream wavelength channel 2 (which uses a second upstream wavelength λ u2), an upstream wavelength channel 3 (which uses a third upstream wavelength λ u3), and an upstream wavelength channel 4 (which uses a fourth upstream wavelength λ u4); the four downstream wavelength channels of the multi-wavelength PON system 100 are separately named a downstream wavelength channel 1 (which uses a first downstream wavelength λ d1), a downstream wavelength channel 2 (which uses a second downstream wavelength λ d2), a downstream wavelength channel 3 (which uses a third downstream wavelength λ d3), and a

downstream wavelength channel 4 (which uses a fourth downstream wavelength λ d4).

[0037] Each upstream wavelength channel and each downstream wavelength channel may have a corresponding wavelength channel identifier (such as a channel number). That is, the upstream wavelength channel identifier matches an upstream wavelength of an upstream wavelength channel identified by the upstream wavelength channel identifier, and the OLT 110 and the ONUs 120 may learn the upstream wavelength of the upstream wavelength channel according to the upstream wavelength channel identifier. Similarly, the downstream wavelength channel identifier also matches a downstream wavelength of a downstream wavelength channel identified by the downstream wavelength channel identifier, and the OLT 110 and the ONUs 120 may learn the downstream wavelength of the downstream wavelength channel according to the downstream wavelength channel identifier.

[0038] In an embodiment, referring to FIG. 2, the OLT 110 may include an optical coupler 111, a first wavelength division multiplexer 112, a second wavelength division multiplexer 113, multiple downstream optical transmitters Tx1–Tx4, multiple upstream optical receivers Rx1–Rx4, and a processing module 114. The multiple downstream optical transmitters Tx1–Tx4 are connected to the optical coupler 111 by using the first wavelength division multiplexer 112, the multiple upstream optical receivers Rx1–Rx4 are connected to the optical coupler 111 by using the second wavelength division multiplexer 113, and the coupler 111 is further connected to the feeder fiber 131 of the ODN 130.

[0039] Transmit wavelengths vary between the multiple downstream optical transmitters Tx1–Tx4. Each downstream optical transmitter of Tx1–Tx4 may correspond to one of the downstream wavelength channels of the multi-wavelength PON system 100. For example, the transmit wavelengths of the multiple downstream optical transmitters Tx1–Tx4 may be λ d1–λ d4. The downstream optical transmitters Tx1–Tx4 may use their respective transmit wavelengths λ d1– λ d4 to transmit downstream data to corresponding downstream wavelength channels separately so that the downstream data is received by the ONUs 120 that work on the downstream wavelength channels. Correspondingly, receive wavelengths may vary between the multiple upstream optical receivers Rx1–Rx4. Each upstream optical receiver of Rx1–Rx4 also corresponds to one of the upstream wavelength channels of the multi-wavelength passive optical network system 100. For example, the ~~transmitter~~ receive

wavelengths of the multiple upstream optical receivers Rx1–Rx4 may be $\lambda u1-\lambda u4$. The upstream optical receivers Rx1–Rx4 may use their respective receive wavelengths $\lambda u1-\lambda u4$ to receive upstream data sent by the ONUs 120 that work on the corresponding upstream wavelength channels.

[0040] The first wavelength division multiplexer 112 is configured to: perform wavelength division multiplexing on the downstream data that is transmitted by the multiple downstream optical transmitters Tx1–Tx4 and whose wavelengths are $\lambda d1-\lambda d4$, so as to form a multi-wavelength downstream optical signal; and use the optical coupler 111 to send the multi-wavelength ~~upstream~~ downstream optical signal to the feeder fiber 131 of the ODN 130, so as to provide the downstream data for the ONUs 120 by using the ODN 130. In addition, the optical coupler 111 may be further configured to provide the second wavelength division multiplexer 113 with multi-wavelength upstream optical signals (which include the upstream data whose wavelengths are $\lambda u1-\lambda u4$) that come from the multiple ONUs 120, and the second wavelength division multiplexer 113 may perform wavelength division demultiplexing on the multi-wavelength upstream optical signals to form the upstream data whose wavelengths are $\lambda u1-\lambda u4$, and provide the upstream data for the upstream optical receivers Rx1–Rx4 to perform data receiving.

[0041] The processing module 114 may be a Media Access Control (Media Access Control, MAC) module or a MAC chip. On the one hand, according to a downstream wavelength channel on which an ONU 120 works, the processing module 114 may provide the downstream data that is to be sent to the ONU 120 for a downstream optical transmitter corresponding to the downstream wavelength channel, so that the downstream optical transmitter transmits the downstream data to the wavelength channel; on the other hand, the processing module 114 may also process the upstream data received by each upstream optical receiver of Rx1–Rx4.

[0042] Working wavelengths (including upstream transmit wavelengths and downstream receive wavelengths) of the ONUs 120 are tunable. In a specific embodiment, each ONU 120 may include an optical coupler 121, a downstream optical receiver 122, an upstream optical transmitter 123, and a processing module 124. Both the downstream optical receiver 122 and the upstream optical transmitter 123 are wavelength-tunable components, and they may be

wavelength and information about the selected downstream receive wavelength to the OLT.

[0057] The ONU may record identifiers of the upstream transmit wavelength and downstream receive wavelength currently selected by the ONU, add the information about the upstream transmit wavelength and the information about the downstream receive wavelength into an upstream data frame or another upstream message sent to the OLT, and report the information to the OLT by using the upstream data frame or the upstream message.

[0058] In a specific embodiment, the information about the upstream transmit wavelength and the information about the downstream receive wavelength may be carried in an XGPON transmission convergence (XGPON Transmission Conversion~~,~~gence, XGTC) frame, a GPON transmission convergence (GPON Transmission Conversion, GTC) frame, or an Ethernet frame (that is, EPON frame) with a logic link identifier (Logic Link Identifier, LLID).

[0059] An example is used, in which the information about the upstream transmit wavelength and the information about the downstream receive wavelength are carried in an XGTC frame. Referring to FIG. 4, the XGTC frame includes an XGTC frame header and an XGTC payload, where the XGTC frame header includes an optical network unit identifier (ONU-ID) field, an indication (Ind) field, a hybrid error correction (Hybrid Error Correction, HEC) field, and a physical layer operations, administration and maintenance upstream (Physical Layer Operations, Administration and Maintenance upstream, PLOAMu) field, where the information about the downstream wavelength and the information about the upstream wavelength may be carried in the Ind field. For example, a 9-bit reserved (Reserve) field is reserved in the Ind field of the XGTC frame header defined in the XGPON standard. In this embodiment, the information about the downstream wavelength and the information about the upstream wavelength may be carried in the reserved field of the Ind field of the XGTC frame header, as shown in FIG. 4.

[0060] Alternatively, in other embodiments, the information about the upstream transmit wavelength and the information about the downstream receive wavelength may be carried in a physical layer operations, administration and maintenance (Physical Layer Operations, Administration and Maintenance, PLOAM) message, an ONT management and control interface (ONT Management and Control Interface, OMCI) message, a Multi-Point Control Protocol (Multi-Point Control Protocol, MPCP) message, or an operation, administration and

CLAIMS

What is claimed is:

1. A wavelength negotiation method of a multi-wavelength passive optical network PON, comprising:

receiving a wavelength status table that is broadcast by an optical line terminal OLT over each downstream wavelength channel of a multi-wavelength PON system, wherein the wavelength status table is used to indicate information about available wavelengths of the multi-wavelength PON system and statistic information of registered optical network units ONUs of a corresponding wavelength channel;

selecting an upstream transmit wavelength and a downstream receive wavelength according to the wavelength status table; and

reporting information about the upstream transmit wavelength and information about the downstream receive wavelength to the OLT so that the OLT refreshes the wavelength status table.

2. The wavelength negotiation method according to claim 1, wherein the wavelength status table comprises a list of currently available upstream wavelengths and a list of currently available downstream wavelengths, and the number of registered ONUs of a wavelength channel corresponding to each wavelength in the list of the available upstream wavelengths and the list of the available downstream wavelengths.

3. The wavelength negotiation method according to claim 1, wherein the wavelength status table comprises a binding relationship list of currently available upstream/downstream transmit/receive wavelengths, and the number of registered ONUs of a wavelength channel corresponding to each upstream/downstream transmit/receive wavelength pair in the binding relationship list of the currently available upstream/downstream transmit/receive wavelengths.

4. The wavelength negotiation method according to claim 2 or 3, wherein the selecting an upstream transmit wavelength and a downstream receive wavelength according to the wavelength status table comprises:

selecting an upstream transmit wavelength and a downstream receive wavelength with a smaller number of registered ONUs or selecting an upstream/downstream transmit/receive wavelength pair with a smaller number of registered ONUs according to the number of registered ONUs of the wavelength channel corresponding to each upstream/downstream wavelength or each upstream/downstream transmit/receive wavelength pair recorded in the wavelength status table and in view of a transmit/receive wavelength capability supported by the ONUs.

5. The wavelength negotiation method according to claim 1, further comprising:

performing wavelength initialization before sending a registration request and configuring a temporary downstream receive wavelength, wherein

the wavelength status table is received from a corresponding downstream wavelength channel by means of the temporary downstream receive wavelength.

6. The wavelength negotiation method according to claim 5, wherein the performing wavelength initialization before sending a registration request and configuring a temporary downstream receive wavelength comprise:

searching for downstream data from the OLT by gradually adjusting the downstream receive wavelength before sending the registration request; and when it is found that a downstream optical signal can be received from the OLT over a downstream receive wavelength to which the downstream receive wavelength is currently adjusted and that a correct downstream data frame can be obtained by parsing the downstream optical signal, configuring the current downstream receive wavelength as the temporary downstream receive wavelength and stopping the adjustment of the downstream receive wavelength.

7. The wavelength negotiation method according to claim 1, further comprising:

generating a corresponding wavelength mapping relationship table entry after the OLT receives an upstream data frame or an upstream message that carries the information about the upstream transmit wavelength and the information about the downstream receive wavelength, wherein the wavelength mapping relationship table entry may comprise ONU identification information and the information about the upstream transmit wavelength and the information about the downstream receive wavelength of each ONU; and

refreshing, by the OLT, statistic information of registered ONUs of a wavelength

channel corresponding to the information about the upstream transmit wavelength and information about a downstream transmitter wavelength in the wavelength state table according to the wavelength mapping relationship table entry.

8. The wavelength negotiation method according to claim 7, further comprising:

refreshing, by the OLT, the wavelength status table according to a wavelength mapping table entry corresponding to a loss of signal alarm when detecting the loss of signal alarm; and

deleting, by the OLT, corresponding wavelength status information of the wavelength status table when detecting a fault of a transceiver component of the OLT.

9. The wavelength negotiation method according to claim 1, further comprising:

reporting an ONU wavelength capability set to the OLT when sending a registration request or after registration succeeds; and

receiving a wavelength status subtable that is reconstructed and returned in a unicast manner by the OLT when it is determined that the upstream transmit wavelength or the downstream receive wavelength selected by each ONU does not meet an expected wavelength requirement, and selecting a new upstream transmit wavelength and a new downstream receive wavelength according to the wavelength status subtable, wherein

the wavelength status subtable comprises information about available wavelengths in transmit/receive wavelengths supported by the ONU and the statistic information of registered ONUs of a corresponding wavelength channel.

10. A wavelength negotiation apparatus of a multi-wavelength passive optical network PON, comprising:

an optical receiver, configured to receive a wavelength status table that is broadcast by an optical line terminal OLT over each downstream wavelength channel of a multi-wavelength PON system, wherein the wavelength status table is used to indicate information about available wavelengths of the multi-wavelength PON system and statistic information of registered optical network units ONUs of a corresponding wavelength channel;

a processor, configured to select an upstream transmit wavelength and a downstream receive wavelength according to the wavelength status table; and

an optical transmitter, configured to report information about the upstream transmit wavelength and information about the downstream receive wavelength to the OLT so that the OLT refreshes the wavelength status table.

11. The wavelength negotiation apparatus according to claim 10, wherein the wavelength status table comprises a list of currently available upstream wavelengths and a list of currently available downstream wavelengths, and the number of registered ONUs of a wavelength channel corresponding to each wavelength in the list of the available upstream wavelengths and the list of the available downstream wavelengths.

12. The wavelength negotiation apparatus according to claim 11, wherein the processor comprises:

a wavelength information obtaining module, configured to: obtain, from the list of the currently available upstream wavelengths and the list of the currently available downstream wavelengths, information about the available upstream wavelengths and information about the available downstream wavelengths, and the numbers of registered ONUs of wavelength channel corresponding to each available upstream wavelength or each available downstream wavelength; and

a wavelength selecting module, configured to select an available upstream wavelength and an available downstream wavelength that correspond to a wavelength channel with a smaller number of registered ONUs as the upstream transmit wavelength and the downstream receive wavelength respectively.

13. The wavelength negotiation apparatus according to claim 10, wherein the wavelength status table comprises a binding relationship list of currently available upstream/downstream transmit/receive wavelengths, and the number of registered ONUs of a wavelength channel corresponding to each upstream/downstream transmit/receive wavelength pair in the binding relationship list of the currently available upstream/downstream transmit/receive wavelengths.

14. The wavelength negotiation apparatus according to claim 13, wherein the processor comprises:

a wavelength information obtaining module, configured to: obtain, from the binding relationship list of the available upstream/downstream transmit/receive wavelengths,

information about available upstream/downstream transmit/receive wavelength pairs, and the number of registered ONUs of a wavelength channel corresponding to information about each available upstream/downstream transmit/receive wavelength pair; and

a wavelength selecting module, configured to select an available upstream/downstream transmit/receive wavelength pair that corresponds to a wavelength channel with a smaller number of registered ONUs as the upstream transmit wavelength and the downstream receive wavelength.

15. The wavelength negotiation apparatus according to claim 10, wherein

the processor is further configured to perform wavelength initialization before sending a registration request, and configure a temporary downstream receive wavelength, wherein the temporary downstream receive wavelength is used as a receive wavelength for receiving the wavelength status table.

16. The wavelength negotiation apparatus according to claim 15, wherein the processor comprises:

a wavelength adjusting module, configured to search for downstream data from the OLT by gradually adjusting the downstream receive wavelength before sending the registration request; and

a temporary wavelength configuring module, configured to: when it is found that a downstream optical signal can be received from the OLT over a downstream receive wavelength to which the downstream receive wavelength is currently adjusted and that a correct downstream data frame can be obtained by parsing the downstream optical signal, configure the current downstream receive wavelength as the temporary downstream receive wavelength and stop the adjustment of the downstream receive wavelength.

17. The wavelength negotiation apparatus according to claim 10, wherein

the optical transmitter is further configured to report an ONU wavelength capability set to the OLT when sending a registration request or after registration succeeds;

the optical receiver is further configured to receive a wavelength status subtable that is reconstructed and returned in a unicast manner by the OLT when it is determined that the selected upstream transmit wavelength or downstream receive wavelength does not meet an expected wavelength requirement; and

the processor is further configured to select a new upstream transmit wavelength and a new downstream receive wavelength according to the wavelength status subtable, wherein

the wavelength status subtable comprises information about available wavelengths in transmit/receive wavelengths supported by each ONU and the statistic information of the registered ONUs of the corresponding wavelength channel.

18. A multi-wavelength passive optical network PON system, comprising at least one optical line terminal OLT and multiple optical network units ONUs, wherein the at least one OLT is connected to the multiple ONUs in a point-to-multipoint manner by using an optical distribution network, wherein the ONUs comprise the wavelength negotiation apparatus of the multi-wavelength PON specified in any one of claims 10 to 17.

CLAIMS

1. A wavelength negotiation method of a multi-wavelength passive optical network PON, comprising:

receiving a wavelength status table that is broadcast by an optical line terminal OLT over each downstream wavelength channel of a multi-wavelength PON system, wherein the wavelength status table is used to indicate information about available wavelengths of the multi-wavelength PON system and statistic information of registered optical network units ONUs of a corresponding wavelength channel, wherein each wavelength channel is capable of carry services of more than one ONUs;

selecting an upstream transmit wavelength and a downstream receive wavelength according to the wavelength status table; and

reporting information about the upstream transmit wavelength and information about the downstream receive wavelength to the OLT so that the OLT refreshes the wavelength status table.

2. The wavelength negotiation method according to claim 1, wherein the wavelength status table comprises a list of currently available upstream wavelengths and a list of currently available downstream wavelengths, and the number of registered ONUs of a wavelength channel corresponding to each wavelength in the list of the available upstream wavelengths and the list of the available downstream wavelengths.

3. The wavelength negotiation method according to claim 1, wherein the wavelength status table comprises a binding relationship list of currently available upstream/downstream transmit/receive wavelengths, and the number of registered ONUs of a wavelength channel corresponding to each upstream/downstream transmit/receive wavelength pair in the binding relationship list of the currently available upstream/downstream transmit/receive wavelengths.

4. The wavelength negotiation method according to claim 2 or 3, wherein the selecting an upstream transmit wavelength and a downstream receive wavelength according to the wavelength status table comprises:

selecting an upstream transmit wavelength and a downstream receive wavelength with a smaller number of registered ONUs or selecting an upstream/downstream transmit/receive wavelength pair with a smaller number of registered ONUs according to the number of registered ONUs of the wavelength channel corresponding to each upstream/downstream wavelength or each upstream/downstream transmit/receive wavelength pair recorded in the wavelength status table and in view of a transmit/receive wavelength capability supported by the ONUs.

5. The wavelength negotiation method according to claim 1, further comprising:

performing wavelength initialization before sending a registration request and configuring a temporary downstream receive wavelength, wherein

the wavelength status table is received from a corresponding downstream wavelength channel by means of the temporary downstream receive wavelength.

6. The wavelength negotiation method according to claim 5, wherein the performing wavelength initialization before sending a registration request and configuring a temporary downstream receive wavelength comprise:

searching for downstream data from the OLT by gradually adjusting the downstream receive wavelength before sending the registration request; and when it is found that a downstream optical signal can be received from the OLT over a downstream receive wavelength to which the downstream receive wavelength is currently adjusted and that a correct downstream data frame can be obtained by parsing the downstream optical signal, configuring the current downstream receive wavelength as the temporary downstream receive wavelength and stopping the adjustment of the downstream receive wavelength.

7. The wavelength negotiation method according to claim 1, further comprising:

generating a corresponding wavelength mapping relationship table entry after the OLT receives an upstream data frame or an upstream message that carries the information about the upstream transmit wavelength and the information about the downstream receive wavelength, wherein the wavelength mapping relationship table entry may comprise ONU identification information and the information about the upstream transmit wavelength and the information about the downstream receive wavelength of each ONU; and

refreshing, by the OLT, statistic information of registered ONUs of a wavelength

channel corresponding to the information about the upstream transmit wavelength and information about a downstream receive wavelength in the wavelength status table according to the wavelength mapping relationship table entry.

8. The wavelength negotiation method according to claim 7, further comprising:

refreshing, by the OLT, the wavelength status table according to a wavelength mapping table entry corresponding to a loss of signal alarm when detecting the loss of signal alarm; and

deleting, by the OLT, corresponding wavelength status information of the wavelength status table when detecting a fault of a transceiver component of the OLT.

9. The wavelength negotiation method according to claim 1, further comprising:

reporting an ONU wavelength capability set to the OLT when sending a registration request or after registration succeeds; and

receiving a wavelength status subtable that is reconstructed and returned in a unicast manner by the OLT when it is determined that the upstream transmit wavelength or the downstream receive wavelength selected by each ONU does not meet an expected wavelength requirement, and selecting a new upstream transmit wavelength and a new downstream receive wavelength according to the wavelength status subtable, wherein

the wavelength status subtable comprises information about available wavelengths in transmit/receive wavelengths supported by the ONU and the statistic information of registered ONUs of a corresponding wavelength channel.

10. A wavelength negotiation apparatus of a multi-wavelength passive optical network PON, comprising:

an optical receiver, configured to receive a wavelength status table that is broadcast by an optical line terminal OLT over each downstream wavelength channel of a multi-wavelength PON system, wherein the wavelength status table is used to indicate information about available wavelengths of the multi-wavelength PON system and statistic information of registered optical network units ONUs of a corresponding wavelength channel, wherein each wavelength channel is capable of carry services of more than one ONUs;

a processor, configured to select an upstream transmit wavelength and a downstream

receive wavelength according to the wavelength status table; and

an optical transmitter, configured to report information about the upstream transmit wavelength and information about the downstream receive wavelength to the OLT so that the OLT refreshes the wavelength status table.

11. The wavelength negotiation apparatus according to claim 10, wherein the wavelength status table comprises a list of currently available upstream wavelengths and a list of currently available downstream wavelengths, and the number of registered ONUs of a wavelength channel corresponding to each wavelength in the list of the available upstream wavelengths and the list of the available downstream wavelengths.

12. The wavelength negotiation apparatus according to claim 11, wherein the processor comprises:

a wavelength information obtaining module, configured to: obtain, from the list of the currently available upstream wavelengths and the list of the currently available downstream wavelengths, information about the available upstream wavelengths and information about the available downstream wavelengths, and the numbers of registered ONUs of wavelength channel corresponding to each available upstream wavelength or each available downstream wavelength; and

a wavelength selecting module, configured to select an available upstream wavelength and an available downstream wavelength that correspond to a wavelength channel with a smaller number of registered ONUs as the upstream transmit wavelength and the downstream receive wavelength respectively.

13. The wavelength negotiation apparatus according to claim 10, wherein the wavelength status table comprises a binding relationship list of currently available upstream/downstream transmit/receive wavelengths, and the number of registered ONUs of a wavelength channel corresponding to each upstream/downstream transmit/receive wavelength pair in the binding relationship list of the currently available upstream/downstream transmit/receive wavelengths.

14. The wavelength negotiation apparatus according to claim 13, wherein the processor comprises:

a wavelength information obtaining module, configured to: obtain, from the binding

relationship list of the available upstream/downstream transmit/receive wavelengths, information about available upstream/downstream transmit/receive wavelength pairs, and the number of registered ONUs of a wavelength channel corresponding to information about each available upstream/downstream transmit/receive wavelength pair; and

a wavelength selecting module, configured to select an available upstream/downstream transmit/receive wavelength pair that corresponds to a wavelength channel with a smaller number of registered ONUs as the upstream transmit wavelength and the downstream receive wavelength.

15. The wavelength negotiation apparatus according to claim 10, wherein

the processor is further configured to perform wavelength initialization before sending a registration request, and configure a temporary downstream receive wavelength, wherein the temporary downstream receive wavelength is used as a receive wavelength for receiving the wavelength status table.

16. The wavelength negotiation apparatus according to claim 15, wherein the processor comprises:

a wavelength adjusting module, configured to search for downstream data from the OLT by gradually adjusting the downstream receive wavelength before sending the registration request; and

a temporary wavelength configuring module, configured to: when it is found that a downstream optical signal can be received from the OLT over a downstream receive wavelength to which the downstream receive wavelength is currently adjusted and that a correct downstream data frame can be obtained by parsing the downstream optical signal, configure the current downstream receive wavelength as the temporary downstream receive wavelength and stop the adjustment of the downstream receive wavelength.

17. The wavelength negotiation apparatus according to claim 10, wherein

the optical transmitter is further configured to report an ONU wavelength capability set to the OLT when sending a registration request or after registration succeeds;

the optical receiver is further configured to receive a wavelength status subtable that is reconstructed and returned in a unicast manner by the OLT when it is determined that the selected upstream transmit wavelength or downstream receive wavelength does not meet an

expected wavelength requirement; and

the processor is further configured to select a new upstream transmit wavelength and a new downstream receive wavelength according to the wavelength status subtable, wherein

the wavelength status subtable comprises information about available wavelengths in transmit/receive wavelengths supported by each ONU and the statistic information of the registered ONUs of the corresponding wavelength channel.

18. A multi-wavelength passive optical network PON system, comprising at least one optical line terminal OLT and multiple optical network units ONUs, wherein the at least one OLT is connected to the multiple ONUs in a point-to-multipoint manner by using an optical distribution network, wherein the ONUs comprise the wavelength negotiation apparatus of the multi-wavelength PON specified in any one of claims 10 to 17.