

Wavelength Indication in Multiple-Wavelength Passive Optical Networks

~~CROSS-REFERENCE TO RELATED APPLICATIONS~~

~~[0001] The present application claims the benefit of U.S. Provisional Patent Application No. 61/473,439 filed April 8, 2011 by Yuanqiu Luo, et al. and entitled "Wavelength Indication in Multiple-Wavelength Passive Optical Networks," and claims the benefit of U.S. Patent Application Serial No. 13/440765 filed April 5, 2012 by Yuanqiu Luo, et al. and entitled "Wavelength Indication in Multiple-Wavelength Passive Optical Networks", which are incorporated herein by reference as if reproduced in their entirety.~~

FIELD OF INVENTION

[0002] The present invention relates to communication network, and more particularly, to wavelength indication in multiple-wavelength passive optical networks.

BACKGROUND

[0003] A passive optical network (PON) is one system for providing network access over "the last mile." The PON is a point to multi-point network comprised of an optical line terminal (OLT) at the central office, an optical distribution network (ODN), and a plurality of optical network units (ONUs) at the customer premises. In some PON systems, such as Gigabit PON (GPON) systems, downstream data is broadcasted at about 2.5 gigabits per second (Gbps) while upstream data is transmitted at about 1.25 Gbps. However, the bandwidth capability of the PON systems is expected to increase as the demands for services increase. To meet the increased demand in services, some emerging PON systems, such as Next Generation Access (NGA) systems, are being reconfigured to transport the data frames with improved reliability and efficiency at higher bandwidths, for example at about ten Gbps.

CLAIMS

1. An apparatus of a passive optical network (PON) comprising:
an optical line terminal (OLT) component configured to couple to an optical network unit (ONU) and send downstream wavelength identification to the ONU to indicate a wavelength that corresponds to the ONU,
wherein the downstream wavelength identification is transmitted using a Media Access Control (MAC) layer frame for an embedded channel, a control message channel, or a data channel.
2. The apparatus of claim 1, wherein the OLT component is further configured to receive upstream wavelength feedback from the ONU that indicates a wavelength that corresponds to the ONU, and wherein the upstream wavelength feedback is transmitted using a second MAC layer frame.
3. The apparatus of claim 2, wherein the downstream wavelength identification is sent when the ONU is assigned a determined downstream wavelength channel and needs to know which downstream wavelength channel is assigned to the ONU, and wherein the upstream wavelength feedback is sent to allow the OLT to associate upstream transmissions from the ONU with the determined downstream wavelength channel.
4. The apparatus of claim 1, wherein the MAC layer frame is a gigabit PON (GPON) downstream frame for an embedded operations, administration, and management (OAM) channel

that comprises a payload length (Plend) field, and wherein the Plend field includes a wavelength identifier (ID) that indicates the wavelength for the ONU.

5. The apparatus of claim 1, wherein the MAC layer frame is a 10 gigabit PON (XGPON) downstream Physical Layer (PHY) frame for an embedded operations, administration, and management (OAM) channel that comprises a PON identifier (ID) field, and wherein the PON ID field includes a wavelength ID that indicates the wavelength for the ONU.

6. The apparatus of claim 1, wherein the MAC layer frame is an Ethernet PON (EPON) or 10 gigabit EPON (10GEAPON) downstream frame for an embedded logical link identifier (LLID) channel that comprises a LLID field, and wherein the LLID field includes a wavelength identifier (ID) that indicates the wavelength for the ONU.

7. The apparatus of claim 1, wherein the MAC layer frame is a modified gigabit PON (GPON) PLOAM message for an embedded control channel that comprises a plurality of octets for bit numbers and various indication, and wherein some of the bits in the octets are used to indicate the wavelength for the ONU.

8. The apparatus of claim 1, wherein the MAC layer frame is a modified 10 gigabit PON (XGPON) PLOAM message for an embedded control channel that comprises a plurality of octets for profile version and index, forward error correction (FEC), and delimiter length, and wherein some of the bits in the octets are used to indicate the wavelength for the ONU.

9. The apparatus of claim 1, wherein the MAC layer frame is a new gigabit PON (GPON) or 10 GPON (XGPON) PLOAM message for an embedded control channel that comprises a plurality of octets, and wherein some of the octets are used to indicate the wavelength for the ONU.

10. The apparatus of claim 1, wherein the MAC layer frame is a modified Ethernet PON (EPON) or 10 gigabit EPON (10GEAPON) multi-point control protocol data unit (MPCPDU) for an embedded control channel that comprises a plurality of octets for grant and pad, and wherein some of the bits in the octets are used to indicate the wavelength for the ONU.

11. The apparatus of claim 1, wherein the MAC layer frame is a new Ethernet PON (EPON) or 10 gigabit EPON (10GEAPON) multi-point control protocol data unit (MPCPDU) for an embedded control channel that comprises a plurality of octets, and wherein some of the octets are used to indicate the wavelength for the ONU.

12. The apparatus of claim 1, wherein the MAC layer frame is a gigabit PON (GPON) or 10 GPON (XGPON) message for a user data channel that indicates the wavelength for the ONU, and wherein a GPON encapsulation method (GEM) or 10 GEM (XGEM) port is configured using an ONT management and control interface (OMCI) for downstream wavelength identification.

13. The apparatus of claim 1, wherein the MAC layer frame is an Ethernet PON (EPON) or 10 gigabit EPON (10GEAPON) message for a user data channel that indicates the wavelength for the ONU, and wherein the EPON or 10GEAPON message includes a broadcast logical link identifier (LLID) configured for downstream wavelength identification.

14. An apparatus of a passive optical network (PON) comprising:

an optical network unit (ONU) component configured to couple to an optical line terminal (OLT) and send upstream wavelength feedback to the OLT to indicate a wavelength that corresponds to the ONU,

wherein the upstream wavelength feedback is transmitted using a Media Access Control (MAC) layer frame for an embedded channel, a control message channel, or a data channel.

15. The apparatus of claim 14, wherein the ONU component is further configured to receive downstream wavelength identification from the OLT that indicates a wavelength that corresponds to the ONU, and wherein the downstream wavelength identification is transmitted using a second MAC layer frame.

16. The apparatus of claim 14, wherein the MAC layer frame is a gigabit PON (GPON) upstream burst header for an embedded operations, administration, and management (OAM) channel that comprises an indication (Ind) field, and wherein the Ind field includes a wavelength identifier (ID) that indicates the wavelength for the ONU.

17. The apparatus of claim 14, wherein the MAC layer frame is a 10 gigabit PON (XGPON) transmission container (XGTC) burst header for an embedded operations, administration, and management (OAM) channel that comprises an ONU identifier (ID) field, and wherein the ONU ID field includes a wavelength ID that indicates the wavelength for the ONU.

18. The apparatus of claim 14, wherein the MAC layer frame is an Ethernet PON (EPON) or 10 gigabit EPON (10GEAPON) upstream frame for an embedded logical link identifier (LLID) channel that comprises a LLID field, and wherein the LLID field includes a wavelength identifier (ID) that indicates the wavelength for the ONU.

19. The apparatus of claim 14, wherein the MAC layer frame is a new gigabit PON (GPON) or 10 GPON (XGPON) PLOAM message for an embedded control channel that comprises a plurality of octets, and wherein some of the octets are used to indicate the wavelength for the ONU.

20. The apparatus of claim 14, wherein the MAC layer frame is a modified gigabit PON (GPON) or 10 gigabit PON (XGPON) acknowledge PLOAM message for an embedded control channel that comprises a modified Serial_Number_ONU field to indicate the wavelength for the ONU.

21. The apparatus of claim 14, wherein the MAC layer frame is a modified Ethernet PON (EPON) or 10 gigabit EPON (10GEAPON) multi-point control protocol data unit (MPCPDU) for

an embedded control channel that comprises a plurality of octets for report and pad, and wherein some of the bits in the octets are used to indicate the wavelength for the ONU.

22. The apparatus of claim 14, wherein the MAC layer frame is a new Ethernet PON (EPON) or 10 gigabit EPON (10GEAPON) multi-point control protocol data unit (MPCPDU) for an embedded control channel that comprises a plurality of octets, and wherein some of the octets are used to indicate the wavelength for the ONU.

23. The apparatus of claim 14, wherein the MAC layer frame is a gigabit PON (GPON) or 10 GPON (XGPON) message for a user data channel that indicates the wavelength for the ONU, and wherein a GPON encapsulation method (GEM) or 10 GEM (XGEM) port is configured using an ONT management and control interface (OMCI) for upstream wavelength feedback.

24. The apparatus of claim 14, wherein the MAC layer frame is an Ethernet PON (EPON) or 10 gigabit EPON (10GEAPON) message for a user data channel that indicates the wavelength for the ONU, and wherein the EPON or 10GEAPON message includes a broadcast logical link identifier (LLID) configured for upstream wavelength feedback.

25. A method implemented at an optical line terminal (OLT) for a passive optical network (PON) comprising:

sending, using a transmitter, a downstream wavelength identification for an optical network unit (ONU) that indicates a wavelength for the ONU in a Media Access Control (MAC) layer frame for an embedded channel, a control message channel, or a data channel.

26. The method of claim 25 further comprising:

receiving, using a receiver, an upstream wavelength feedback for the OLT that indicates a wavelength for the ONU in a MAC layer frame for the same channel of the downstream wavelength identification.

27. The method of claim 25, wherein the indicated wavelength is a downstream wavelength transmitted from the OLT to the ONU, and wherein the wavelength is indicated to the ONU in the MAC layer frame to configure the ONUs' receiver.

28. The method of claim 25, wherein the indicated wavelength is an upstream wavelength transmitted from the ONU to the OLT, and wherein the wavelength is indicated to the ONU in the MAC layer frames to configure the ONUs' transmitter.

29. The method of claim 25, wherein the indicated wavelength is a downstream wavelength transmitted from the OLT to the ONU, and wherein the wavelength is indicated to the ONU in the MAC layer frame to synchronize transmissions between the OLT and the ONU.

30. The method of claim 25, wherein the indicated wavelength is an upstream wavelength transmitted from the ONU to the OLT, and wherein the wavelength is indicated to the ONU in the MAC layer frame to synchronize transmissions between the OLT and the ONU.

31. The method of claim 25, wherein the MAC layer frame indicates the wavelength using a wavelength identifier (ID) that corresponds to the wavelength.

32. The method of claim 25, wherein the MAC layer frame indicates the wavelength using an absolute value for the wavelength.

33. The method of claim 25, wherein the MAC layer frame indicates the wavelength using a relative value for the wavelength to a pre-determined absolute benchmark value.

34. A method implemented at an optical network unit (ONU) for a passive optical network (PON) comprising:

sending, using a transmitter, an upstream wavelength feedback for an optical line terminal (OLT) that indicates a wavelength for the ONU in a Media Access Control (MAC) layer frame for an embedded channel, a control message channel, or a data channel.

35. The method of claim 34 further comprising:

receiving, using a receiver, a downstream wavelength identification for the ONU that indicates a wavelength for the ONU in a MAC layer frame for the same channel of the upstream wavelength feedback.

36. The method of claim 34, wherein the indicated wavelength is a downstream wavelength transmitted from the OLT to the ONU, and wherein the wavelength is indicated in the MAC layer frame to confirm to the OLT the wavelength at the ONUs' receiver.

37. The method of claim 34, wherein the indicated wavelength is an upstream wavelength transmitted from the ONU to the OLT, and wherein the wavelength is indicated in the MAC layer frame to confirm to the OLT the wavelength at the ONU's transmitter.

38. The method of claim 34, wherein the indicated wavelength is a downstream wavelength transmitted from the OLT to the ONU, and wherein the wavelength is indicated to the OLT in the MAC layer frame to synchronize transmissions between the OLT and the ONU.

39. The method of claim 34, wherein the indicated wavelength is an upstream wavelength transmitted from the ONU to the OLT, and wherein the wavelength is indicated to the OLT in the MAC layer frame to synchronize transmissions between the OLT and the ONU.

40. The method of claim 34, wherein the MAC layer frame indicates the wavelength using a wavelength identifier (ID) that corresponds to the wavelength.

41. The method of claim 34, wherein the MAC layer frame indicates the wavelength using an absolute value for the wavelength.

42. The method of claim 34, wherein the MAC layer frame indicates the wavelength using a relative value for the wavelength to a pre-determined absolute benchmark value.

CLAIMS

1. An apparatus of a passive optical network (PON) comprising:

an optical line terminal (OLT) component configured to couple to an optical network unit (ONU) and send downstream wavelength identification to the ONU to indicate a wavelength that
5 corresponds to the ONU,

wherein the downstream wavelength identification is transmitted using a downstream physical layer frame comprising a physical synchronization block (PSBd), wherein the PSBd comprises a PON identifier (ID) field, and wherein the PON ID field includes a wavelength ID that indicates the wavelength for the ONU.

10 2. The apparatus of claim 1, wherein the OLT component is further configured to receive upstream wavelength feedback from the ONU that indicates a wavelength that corresponds to the ONU, and wherein the upstream wavelength feedback is transmitted using an upstream physical layer frame.

15 3. The apparatus of claim 2, wherein the downstream wavelength identification is sent when the ONU is assigned a determined downstream wavelength channel and needs to know which downstream wavelength channel is assigned to the ONU, and wherein the upstream wavelength feedback is sent to allow the OLT to associate upstream transmissions from the ONU with the
20 determined downstream wavelength channel.

4. The apparatus of claim 1, wherein the downstream physical layer frame is a multi wavelength PON downstream frame for an embedded operations, administration, and

management(OAM) channel that comprises a payload length (Plend) field, and wherein the Plend field includes a wavelength identifier (ID) that indicates the wavelength for the ONU.

5 5. The apparatus of claim 1, wherein the downstream physical layer frame is a multi wavelength PON downstream Physical Layer (PHY) frame for an embedded operations, administration, and management(OAM) channel that comprises the PON identifier (ID) field.

10 6. The apparatus of claim 1, wherein the downstream physical layer frame is multi wavelength PON downstream frame for an embedded logical link identifier (LLID) channel that comprises a LLID field, and wherein the LLID field includes a wavelength identifier (ID) that indicates the wavelength for the ONU.

15 7. The apparatus of claim 1, wherein the downstream physical layer frame is a multi-point control protocol data unit (MPCPDU) for an embedded control channel that comprises a plurality of octets for grant and pad, and wherein some of the bits in the octets are used to indicate the wavelength for the ONU.

20 8. The apparatus of claim 1, wherein the downstream physical layer frame is a multi-point control protocol data unit (MPCPDU) for an embedded control channel that comprises a plurality of octets, and wherein some of the octets are used to indicate the wavelength for the ONU.

9. 9. The apparatus of claim 1, wherein the downstream physical layer frame is a multi wavelength PON message for a user data channel that indicates the wavelength for the ONU.

10. The apparatus of claim 1, wherein the downstream physical layer frame is a multi wavelength PON message for a user data channel that indicates the wavelength for the ONU, and wherein the multi wavelength PON message includes a broadcast logical link identifier (LLID) configured for downstream wavelength identification.

11. An apparatus of a passive optical network (PON) comprising:

an optical network unit (ONU) component configured to couple to an optical line terminal (OLT) and send upstream wavelength feedback to the OLT to indicate a wavelength that corresponds to the ONU,

wherein the upstream wavelength feedback is transmitted using an upstream physical layer frame comprising a physical synchronization block (PSBd), wherein the PSBd comprises a PON identifier (ID) field, and wherein the PON ID field includes a wavelength ID that indicates the wavelength for the OLT.

12. The apparatus of claim 11, wherein the ONU component is further configured to receive downstream wavelength identification from the OLT that indicates a wavelength that corresponds to the ONU, and wherein the downstream wavelength identification is transmitted using a downstream physical layer frame.

13. The apparatus of claim 11, wherein the upstream physical layer frame is a multi-point control protocol data unit (MPCPDU) for an embedded control channel that comprises a plurality

of octets for report and pad, and wherein some of the bits in the octets are used to indicate the wavelength for the ONU.

14. The apparatus of claim 11, wherein the upstream physical layer frame is a multi-point control protocol data unit (MPCPDU) for an embedded control channel that comprises a plurality of octets, and wherein some of the octets are used to indicate the wavelength for the ONU.

15. An apparatus of a passive optical network (PON) comprising:

an optical network unit (ONU) component configured to couple to an optical line terminal (OLT) and send upstream wavelength feedback to the OLT to indicate a wavelength that corresponds to the ONU,

wherein the upstream wavelength feedback is transmitted using an upstream physical layer operations, administration, and management (PLOAM) message for an embedded control channel.

16. The apparatus of claim 15, wherein the upstream PLOAM message comprises a plurality of octets, and wherein some of the octets are used to indicate the wavelength for the ONU.

17. The apparatus of claim 15, wherein the upstream PLOAM message comprises a modified Serial_Number_ONU field to indicate the wavelength for the ONU.

18. A method implemented at an optical line terminal (OLT) for a passive optical network (PON) comprising:

5 sending, using a transmitter, a downstream wavelength identification for an optical network unit (ONU) that indicates a wavelength for the ONU in a downstream physical layer frame comprising a physical synchronization block (PSBd), wherein the PSBd comprises a PON identifier (ID) field, and wherein the PON ID field includes a wavelength ID that indicates the wavelength for the ONU.

10 19. The method of claim 18, wherein the indicated wavelength is a downstream wavelength transmitted from the OLT to the ONU, and wherein the wavelength is indicated to the ONU in the downstream physical layer frame to configure the ONUs' receiver.

20 20. The method of claim 18, wherein the indicated wavelength is an upstream wavelength transmitted from the ONU to the OLT, and wherein the wavelength is indicated to the ONU in the downstream physical layer frames to configure the ONUs' transmitter.

15 21. The method of claim 18, wherein the indicated wavelength is a downstream wavelength transmitted from the OLT to the ONU or an upstream wavelength transmitted from the ONU to the OLT, and wherein the wavelength is indicated to the ONU in the downstream physical layer frame to synchronize transmissions between the OLT and the ONU.

20 22. The method of claim 18, wherein the downstream physical layer frame indicates the wavelength using a wavelength ID that corresponds to the wavelength.

23. The method of claim 18, wherein the downstream physical layer frame indicates the wavelength using an absolute value for the wavelength.

24. The method of claim 18, wherein the downstream physical layer frame indicates the wavelength using a relative value for the wavelength to a pre-determined absolute benchmark value.

25. A method implemented at an optical network unit (ONU) for a passive optical network (PON) comprising:

sending, using a transmitter, an upstream wavelength feedback for an optical line terminal (OLT) that indicates a wavelength for the ONU in an upstream physical layer frame comprising a physical synchronization block (PSBd), wherein the PSBd comprises a PON identifier (ID) field, and wherein the PON ID field includes a wavelength ID that indicates the wavelength for the OLT.

26. The method of claim 25 further comprising:

receiving, using a receiver, a downstream wavelength identification for the ONU that indicates a wavelength for the ONU in a downstream physical layer layer frame for the same channel of the upstream wavelength feedback.