UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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NOKIA OF AMERICA CORPORATION *et al.*,

Petitioners

v.

SPADA INNOVATIONS, INC.,

Patent Owner

_____

Case No. IPR2025-01442

U.S. Patent No. 11,589,142

_____

DECLARATION OF DR. MAREK HAJDUCZENIA

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A. Shin-Young Ahn & Jae-Doo Huh, entitled "A Study on Ethernet-PON System functionality for L2/L2 MPLS based VPN service" ("Ahn;" Ex. 1015)....49

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XII. Ground 1: The combination of Ahn in view of G.984.1, G.984.3, and RFC 4364 renders claims 1-9 obvious. 67

A. Alleged Novelty 68

B. Motivation to Combine 70

C. Claim 5 78

1. [5.PRE] A digital network communication method comprises: 78
2. [5.A] receiving from at least one passive optical network (PON) interface router out of a plurality of PON interface routers at a PON optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices;.....79
3. [5.B] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed; 91
4. [5.C] distributing said common data feed to said plurality of ONUs; 95
5. [5.D]/[5.E] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs; 98
6. [5.F] delivering said common data feed to said plurality of ONUs; 101
7. [5.G] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed; 103
8. [5.H] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices. 105

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D. Claim 6 - The method of claim 5, wherein said at least one of said plurality of ONUs provides services to at least one private user of a plurality of users. 108

E. Claim 7 - The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream comprising said IP data packages to said PON OLT. 112

F. Claim 8 115

1. [8.PRE] A digital network communication method comprises: 115
2. [8.A] receiving at a passive optical network (PON) optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices; 115
3. [8.B] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed; 116
4. [8.C] distributing said common data feed to said plurality of ONUs; 116
5. [8.D]/[8.E] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs; 116
6. [8.F] delivering said common data feed to said plurality of ONUs; 116
7. [8.G] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed; 116

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8. [8.H] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices. 116

G. Claim 9 - The method of claim 8, wherein said at least one of said plurality of ONUs provides services to at least one private user our [*sic*] of plurality of users. 116

H. Claim 1 117

1. [1.PRE] A digital data network communication method comprises: 117
2. [1.A] accepting a plurality of data streams into a primary passive optical network (PON) interface router, interconnected with a secondary PON interface router serving a plurality of user devices through a plurality of optical network units (ONUs);.....117
3. [1.B] configuring said primary PON interface router to virtually separate the information intended for at least one private user device of a plurality of user devices, wherein said at least one private user device of a plurality of user devices is connected to at least one of said plurality of ONUs; 123
4. [1.C]/[1.D] wherein said configuring comprises: generating at least one independently unique virtual routing table by using Virtual Routing and Forwarding (VRF); 125
5. [1.E] virtually separating at least one private data stream intended for said at least one private user device from said plurality of data streams using said at least one independently unique virtual routing table to create at least one virtually separated private data stream containing Internet Protocol (IP) data packages;.....129
6. [1.F] uniquely labelling said IP data packages contained in said at least one virtually separated private data stream using Multi-Protocol Label Switching (MPLS) to create MPLS labelled data packages;.....131
7. [1.G] sending said plurality of data streams, including said at least one virtually separated private data stream comprising said MPLS labelled data packages, to said secondary PON interface router;.....132

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8. [1.H] receiving said plurality of data streams including said at least one virtually separated private data stream at said secondary PON interface router; 134
9. [1.I] converting said MPLS labelled data packages contained within said at least one virtually separated private data stream back to said IP data packages; 136
10. [1.J] forwarding said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages from said secondary PON interface router to a PON optical line terminal (OLT); 137
11. [1.K] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed; 139
12. [1.L] distributing said common data feed to said plurality of ONUs; 145
13. [1.M]/[1.N] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs; 147
14. [1.O] delivering said common data feed to said plurality of ONUs; 150
15. [1.P] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed; 152
16. [1.Q] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices. 154

I. Claim 2 – The method of claim 1, wherein said at least one of said plurality of ONUs provides services to at least one private user of plurality of users 156

J. Claim 3 – The method of claim 1, wherein said secondary PON interface router is serially connected to at least one additional PON interface router that is serially connected to said PON OLT, wherein said least one additional PON interface router delivers said plurality of data streams including said at least one virtually

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separated private data stream containing said IP data packages to said PON OLT.....156

K. Claim 4 – The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.....159

XIII. Ground 2: The combination of Ahn in view of G.984.1, G.984.3 RFC 4364, and BCM56685 renders claims 4 and 7 obvious.....162

A. Motivation to Combine 163

B. Claim 7 - The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream comprising said IP data packages to said PON OLT. 165

C. Claim 4 – The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.....168

XIV. Ground 3: The combination of G.984.1 in view G.984.3, RFC 4364, and Ravindran renders claims 1-9 obvious. 172

A. Motivation to Combine 172

B. Claim 5 177

1. [5.PRE] A digital network communication method comprises: 177

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2. [5.A] receiving from at least one passive optical network (PON) interface router out of a plurality of PON interface routers at a PON optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices;.....178
3. [5.B] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed; 186
4. [5.C] distributing said common data feed to said plurality of ONUs; 188
5. [5.D]/[5.E] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs; 190
6. [5.F] delivering said common data feed to said plurality of ONUs; 192
7. [5.G] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed; 192
8. [5.H] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices. 194

C. Claim 6 - The method of claim 5, wherein said at least one of said plurality of ONUs provides services to at least one private user of a plurality of users. 196

D. Claim 7 - The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams

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including said at least one virtually separated private data stream comprising said IP data packages to said PON OLT. 198

E. Claim 8 200

1. [8.PRE] A digital network communication method comprises: 200
2. [8.A] receiving at a passive optical network (PON) optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices; 201
3. [8.B] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed; 201
4. [8.C] distributing said common data feed to said plurality of ONUs; 201
5. [8.D]/[8.E] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs; 201
6. [8.F] delivering said common data feed to said plurality of ONUs; 202
7. [8.G] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed; 202
8. [8.H] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices. 202

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F. Claim 9 - The method of claim 8, wherein said at least one of said plurality of ONUs provides services to at least one private user our of plurality of users. 202
G. Claim 1 202
1. [1.PRE] A digital data network communication method comprises: 202
2. [1.A] accepting a plurality of data streams into a primary passive optical network (PON) interface router, interconnected with a secondary PON interface router serving a plurality of user devices through a plurality of optical network units (ONUs); 203
3. [1.B] configuring said primary PON interface router to virtually separate the information intended for at least one private user device of a plurality of user devices, wherein said at least one private user device of a plurality of user devices is connected to at least one of said plurality of ONUs; 206
4. [1.C]/[1.D] wherein said configuring comprises: generating at least one independently unique virtual routing table by using Virtual Routing and Forwarding (VRF); 207
5. [1.E] virtually separating at least one private data stream intended for said at least one private user device from said plurality of data streams using said at least one independently unique virtual routing table to create at least one virtually separated private data stream containing Internet Protocol (IP) data packages; 211
6. [1.F] uniquely labelling said IP data packages contained in said at least one virtually separated private data stream using Multi-Protocol Label Switching (MPLS) to create MPLS labelled data packages; 214
7. [1.G] sending said plurality of data streams, including said at least one virtually separated private data stream comprising said MPLS labelled data packages, to said secondary PON interface router; 216
8. [1.H] receiving said plurality of data streams including said at least one virtually separated private data stream at said secondary PON interface router; 217

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9. [1.I] converting said MPLS labelled data packages contained within said at least one virtually separated private data stream back to said IP data packages; 219
10. [1.J] forwarding said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages from said secondary PON interface router to a PON optical line terminal (OLT); 220
11. [1.K] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed; 223
12. [1.L] distributing said common data feed to said plurality of ONUs; 226
13. [1.M]/[1.N] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs; 228
14. [1.O] delivering said common data feed to said plurality of ONUs; 230
15. [1.P] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed; 231
16. [1.Q] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices. 233

H. Claim 2 – The method of claim 1, wherein said at least one of said plurality of ONUs provides services to at least one private user of plurality of users 235

I. Claim 3 – The method of claim 1, wherein said secondary PON interface router is serially connected to at least one additional PON interface router that is serially connected to said PON OLT, wherein said least one additional PON interface router delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT. 235

J. Claim 4 – The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT,

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wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.....237

XV. Ground 4: The combination of G.984.1 in view G.984.3, RFC 4364, Ravindran, and BCM56685 renders claims 4 and 7 obvious. 240

A. Motivation to Combine 241

B. Claim 7 - The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream comprising said IP data packages to said PON OLT. 243

C. Claim 4 – The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.....246

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Exhibit	Short Name	Description
Ex. 1001	’142 Patent	U.S. Patent No. 11,589,142
Ex. 1002	Hajduczenia Dec.	Declaration of Dr. Marek Hajduczenia
Ex. 1003	Hajduczenia CV	*Curriculum Vitae* of Dr. Marek Hajduczenia
Ex. 1004	’142 FH	File History of U.S. Patent No. 11,589,142
Ex. 1005	’042 FH	File History of U.S. Patent Application No. 17/128,042
Ex. 1006	’302 FH	File History of U.S. Patent Application No. 16/600,302
Ex. 1007	’602 FH	File History of U.S. Patent Application No. 16/431,602
Ex. 1008	’315 FH	File History of U.S. Patent Application No. 15/351,315
Ex. 1009	’092 FH	File History of U.S. Patent Application No. 14/419,092
Ex. 1010	’997 Prov FH	File History of U.S. Patent Application No. 61/678,997
Ex. 1011	G.984.1	ITU-T Recommendation G.984.1, Gigabit-capable Passive Optical Networks (G-PON): General Characteristics (Mar. 2008)
Ex. 1012	G.984.2	ITU-T Recommendation G.984.2, Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) Layer Specification (Mar. 2003)
Ex. 1013	G.984.3	ITU-T Recommendation G.984.3, Gigabit-capable Passive Optical Networks (G-PON): Transmission convergence layer specification (Mar. 2008)

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Exhibit	Short Name	Description
Ex. 1014	RFC 4364	Network Working Group Request for Comments: 4364: BGP/MPLS IP Virtual Private Networks (VPNs) (Feb. 2006)
Ex. 1015	Ahn	*Certified English Translation of* Shin-Young Ahn, *et al*., A student on Ethernet-PON System functionality for L2/L3 MPLS based VPN service (Nov. 2002)
Ex. 1016	Ravindran	U.S. Patent Publication No. 2012/0159176 to Ravindran, *et al*.
Ex. 1017	Liu	U.S. Patent No. 6,005,694
Ex. 1018	Ramaswami	Rajiv Ramaswami & Kumar Sivarajan, *Optical Networks, A Practical Perspective* (2d ed. 2002)
Ex. 1019	Kramer	Glen Kramer & Gerry Pesavento, *Ethernet Passive Optical Network (EPON): Building a Next-Generation Optical Access Network*, IEEE Communications Magazine (February 2002)
Ex. 1020	BCM56685	Broadcom BCM56685 Product Brief
Ex. 1021	Wayback Affidavit	Affidavit of Mina Ching, Records Request Processor at the Internet Archive regarding public availability of BCM56685
Ex. 1022	EPON v. GPON	*What is the Difference Between EPON and GPON?*, HITRON, https://us.hitrontech.com/learn/what-is-the-difference-between-epon-and-gpon/ (last accessed August 3, 2025)
Ex. 1023	EPON Call for Interest	10Gbps PHY for EPON Call for Interest (Mar. 7, 2006)

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Exhibit	Short Name	Description
Ex. 1024	Ahn	*Original Korean Language version of* Shin-Young Ahn, *et al*., A student on Ethernet-PON System functionality for L2/L3 MPLS based VPN service (Nov. 2002)
Ex. 1025	G.983 Standards	Collectively, ITU-T Recommendations G.983.1, G.983.2, G.983.3, G.983.4
Ex. 1026	Scheduling Order	*SPADA Innovations, Inc., v. AT&T Corp., et al.,* Case No. 2:24-cv-06703-MWF-MAR, Dkt. No. 61 (C.D.C.A. Aug. 7, 2025), Order Re Jury Trial, Order Re Deadlines
Ex. 1027	Complaint	*SPADA Innovations, Inc., v. AT&T Corp., et al.,* Case No. 2:24-cv-06703-MWF-MAR, Dkt. No. 1 (C.D.C.A. Aug. 7, 2024), Complaint
Ex. 1028	Opposition to MTD	*SPADA Innovations, Inc., v. AT&T Corp., et al.,* Case No. 2:24-cv-06703-MWF-MAR, Dkt. No. 31 (C.D.C.A. Dec. 16, 2024), Spada Innovations, Inc.'s Opposition to Defendants' Motion to Dismiss Amended Complaint
Ex. 1029	Dec. to Opposition to MTD	*SPADA Innovations, Inc., v. AT&T Corp., et al.,* Case No. 2:24-cv-06703-MWF-MAR, Dkt. No. 31 (C.D.C.A. Dec. 16, 2024), Declaration in Support of Spada Innovations, Inc.'s Opposition to Defendants' Motion to Dismiss Amended Complaint
Ex. 1030	Hall-Ellis Dec.	Declaration of Dr. Sylvia D. Hall-Ellis
Ex. 1031	Hall-Ellis CV	*Curriculum Vitae* of Dr. Sylvia D. Hall-Ellis
Ex. 1032	Attachment 1A	Hall-Ellis Declaration Attachment 1A
Ex. 1033	Attachment 1B	Hall-Ellis Declaration Attachment 1B

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Exhibit	Short Name	Description
Ex. 1034	Attachment 1C	Hall-Ellis Declaration Attachment 1C
Ex. 1035	Attachment 1D	Hall-Ellis Declaration Attachment 1D
Ex. 1036	Attachment 1E	Hall-Ellis Declaration Attachment 1E
Ex. 1037	Attachment 2A	Hall-Ellis Declaration Attachment 2A
Ex. 1038	Attachment 2B	Hall-Ellis Declaration Attachment 2B
Ex. 1039	Attachment 3A	Hall-Ellis Declaration Attachment 3A
Ex. 1040	Attachment 3B	Hall-Ellis Declaration Attachment 3B
Ex. 1041	Attachment 4A	Hall-Ellis Declaration Attachment 4A
Ex. 1042	Attachment 4B	Hall-Ellis Declaration Attachment 4B
Ex. 1043	Attachment 4C	Hall-Ellis Declaration Attachment 4C
Ex. 1044	Attachment 4D	Hall-Ellis Declaration Attachment 4D
Ex. 1045	Attachment 5A	Hall-Ellis Declaration Attachment 5A
Ex. 1046	Attachment 5B	Hall-Ellis Declaration Attachment 5B
Ex. 1047	Attachment 5C	Hall-Ellis Declaration Attachment 5C
Ex. 1048	Attachment 5D	Hall-Ellis Declaration Attachment 5D
Ex. 1049	Attachment 5E	Hall-Ellis Declaration Attachment 5E
Ex. 1050	Attachment 5F	Hall-Ellis Declaration Attachment 5F

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I, Dr. Marek Hajduczenia, do hereby declare and say as follows:

I. Introduction

1. I have personal knowledge of the facts contained in this Declaration, am of legal age, and am otherwise competent to testify.

2. I have been retained as a technical expert by counsel for Petitioners Nokia of America Corporation ("Nokia" or "Petitioners") as an independent expert in this proceeding before the United States Patent and Trademark Office ("PTO") Patent Trial and Appeal Board ("PTAB") regarding U.S. Patent No. 11,589,142 ("the '142 patent").

3. Unless otherwise stated, the matters contained in this Declaration are of my own personal knowledge and, if called as a witness, I could and would testify completely and truthfully with regard to the matters set forth herein.

4. My opinions are based on my years of education, research, and experience, as well as my study of the relevant materials. A list of materials I considered is included in the Table of Exhibits at the beginning of this Declaration.

5. I reserve all available rights to supplement this Declaration if further information becomes available, or if I am asked to consider additional information. This Declaration represents only those opinions I have formed to date.

6. Further, I reserve all available rights to consider and comment on any additional expert statements or testimony of Patent Owner's expert(s) in this matter.

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7. I am being compensated at my usual consulting rate of $500 per hour for my time spent working on issues in this matter. My compensation does not depend on the outcome of this matter or the opinions I express.

II. Qualifications

8. A true and correct copy of my curriculum vitae is attached as Ex. 1003 to this Declaration.

9. I hold a Ph.D. in Electrical Engineering with a specialization in Optical Communication Systems and have over fifteen years of professional experience in the telecommunications and networking industry. My career has been focused on network architecture, system design, and the development of industry standards, particularly in access and transport networks. This dual focus on both creating the foundational standards and implementing them in large-scale production networks has given me a perspective on the entire technology lifecycle. My expertise encompasses a wide range of technologies, including advanced Layer 2 and Layer 3 networking, Virtual Routing and Forwarding (VRF) concepts, and a long-term, continuous involvement with the evolution of Passive Optical Network (PON) technologies from their initial standardization to the deployment of complex national-level deployments. I have been involved in the standardization development of at least 4 different PON standards, including both IEEE and ITU-T PON system variants.

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10. My professional experience provides me with a comprehensive understanding of the technologies pertinent to this matter. From October 2004 to September 2008, while at Siemens/Nokia Siemens, my work included developing the system architecture for GPON-class access solutions. This role required a detailed analysis of customer requirements for bandwidth management and, critically, service isolation through meticulous Virtual Local Area Network (VLAN) allocation schemes. This work is a foundational precursor to modern network virtualization, as it involves segregating traffic streams to prevent interference and ensure security between different users or service types on the same physical infrastructure. I was directly involved in analyzing security threats inherent in shared-medium PON systems and architecting solutions for future access platforms that included virtual routing capabilities. This involved designing systems that could maintain separate routing and forwarding tables within a single physical device, the core principle of VRF, to deliver isolated network environments to different subscribers. Concurrently, I was deeply engaged in the standardization of 10G-EPON as an Assistant Editor for the IEEE P802.3av project, where I helped shape the physical layer and control plane specifications that would govern the next generation of IEEE PON systems.

11. From September 2008 to September 2013, as the xPON Standardization Director for ZTE's Fixed Access Product Line, I led a team focused on technology

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and standards development in organizations including the IEEE, ITU-T, and Broadband Forum. In this capacity, I was a primary author and contributor to over 500 technical and editorial proposals for a multitude of standards. These contributions addressed complex issues within standards defining 10G-EPON (IEEE 802.3av), 10G-PON (ITU-T G.987 series), and Energy-Efficient Ethernet (IEEE 802.3az), among others. This position gave me a global perspective on the evolution of PON technology, the intricate technical trade-offs involved in developing interoperable, high-performance networking solutions, and the reasoning behind the adoption or rejection of various technical approaches.

12. My tenure at Bright House Networks and then with Charter Communications (when Bright House Networks was acquired) as a Distinguished Engineer from September 2013 to March 2025 involved the practical application and evolution of these technologies at a national scale. My responsibilities included:

- **Passive Optical Network (PON) Architecture:** I was responsible for the complete lifecycle of PON systems, including the rigorous lab evaluation, interoperability testing, and firmware validation of Optical Line Terminal (OLT) and Optical Network Unit (ONU) products from a wide array of vendors. I planned and executed network-wide upgrades from legacy 1G-EPON systems to 10G-EPON platforms across a national footprint, a complex undertaking that required developing meticulous migration

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strategies to ensure service continuity for thousands of customers. This work extended to architecting the future evolution towards 25G-EPON and 50G-PON systems, which involves assessing next-generation silicon capabilities, optical component performance, and the protocol enhancements needed to meet future bandwidth demands.

- **Advanced Network Architecture and VRF:** I was a principal architect for Charter's national Fiber Internet Access (FIA) and L2 Ethernet services, which were built upon a sophisticated EVPN-based underlay. This architecture is a direct and large-scale implementation of VRF principles, using EVPN as the control plane to create and manage thousands of isolated virtual network instances over a shared physical infrastructure. This was critical for delivering enterprise services like E-Line and E-LAN, where each customer is provided a secure, private network. My work also included designing the national QoS policy, architecting dynamic BGP signaling for video CDN prefix distribution, and implementing RPKI-enabled routing security at the network edge to protect the integrity of the routing domain.

13. A significant portion of my career has been dedicated to innovation and the development of intellectual property. I am a named inventor on over 36 utility patents issued by the U.S. Patent and Trademark Office, with many of these also

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registered internationally. Furthermore, I have over 70 additional utility patent submissions in various stages of review and filing. This extensive experience has provided me with a deep and practical understanding of the patenting process, from conception and invention disclosure to navigating office actions, claim construction, prosecution, and the detailed analysis of prior art. My active, long-term participation in standards bodies like the IEEE and ITU-T, where I have served as a contributor, editor, and chair on numerous projects, has further honed my ability to distinguish between truly novel concepts and the existing state of the art. This involvement has given me insight not only into the final published standards but also into the technical debates, alternative proposals, and rationale behind the specific design choices that define the boundaries of established knowledge in the field of networking and telecommunications.

III. Scope of the Engagement

14. I have been retained by Alston & Bird LLP on behalf of Petitioners to provide various analyses and opinions. Among other tasks, I have been asked to address the technology claimed in the ’142 patent and to evaluate whether certain claims of the ’142 patent would have been obvious to a person of ordinary skill in the art.

15. My opinions are based on my experience and knowledge and the information I have reviewed as of the date of this Declaration. In connection with

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my analysis, I have reviewed the exhibits listed in the above list of exhibits, as well as each of the items referenced herein. My opinions directed to the invalidity of the challenged claims are based, at least in part, on the following prior art publications:

- **"G.984.1"** (Ex. 1011), which is ITU-T Recommendation G.984.3 titled Gigabit-capable Passive Optical Networks (G-PON): General Characteristics, was published March 2008.
- **"G.984.2"** (Ex. 1012), which is ITU-T Recommendation G.984.3 titled Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) Layer Specification, was published March 2003.
- **"G.984.3"** (Ex. 1013), which is ITU-T Recommendation G.984.3 titled Gigabit-capable Passive Optical Networks (G-PON): Transmission convergence layer specification, was published March 2008.
- "**RFC 4364**" (Ex. 1014), which is a request for comments titled "BGP/MPLS IP Virtual Private Networks (VPNs)" published February 2006.
- Shin-Young Ahn & Jae-Doo Huh ("**Ahn**"; Ex. 1015), titled "A Study on Ethernet-PON System functionality for L2/L2 MPLS based VPN service" published November 2002 (Ex. 1030, ¶¶ 62-65).
- U.S. Patent Publication No. 2012/0159176 to Ravindran ("**Ravindran**"; Ex. 1016), published July 21, 2012.

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IV. Legal Standards

16. For purposes of this Declaration, counsel has instructed me to make the following assumptions:

17. Claims are construed from the perspective of a person of ordinary skill in the art ("POSITA") as of the effective filing date of the patent application. Persons of ordinary skill in the art are deemed to read the claims in the context of the entire patent, including the specification and prosecution history. In other words, the terms are not considered in a vacuum.

18. It is my understanding that information that satisfies one of the categories of prior art set forth in 35 U.S.C. § 102 may be used in an invalidity analysis under §§ 102 or 103. If information is not properly classified as prior art under one of the subsections of § 102 of the Patent Act, then it may not form the basis of an anticipation or obviousness determination. It is also my understanding that, for *inter partes* review, applicable prior art is limited to patents and printed publications.

19. I am also informed and understand that a patent claim is invalid under 35 U.S.C. § 103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time of the invention to a POSITA to which the subject matter pertains. Obviousness, I am informed, is determined based on the scope and content of the prior art, the

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differences between the prior art and the claim, the level of ordinary skill in the art, and secondary indications of non-obviousness to the extent they exist.

20. I understand that whether there are any relevant differences between the prior art and the claimed invention is to be analyzed from the view of a POSITA at the time of the invention. A POSITA is a hypothetical person who is presumed to be aware of all of the relevant art at the time of the invention. The POSITA is not an automaton and may be able to fit together the teachings of multiple patents (or other printed publications) by employing ordinary creativity and the common sense that familiar items may have obvious uses in another context or beyond their primary purposes.

21. In analyzing the relevance of the differences between the claimed invention and the prior art, I understand that I must consider the impact, if any, of such differences on the obviousness or non-obviousness of the invention as a whole, not merely some portion of it. The person of ordinary skill faced with a problem is able to apply his or her experience and ability to solve the problem and also look to any available prior art to help solve the problem.

22. I understand that an invention would have been obvious if a POSITA, facing the wide range of needs created by developments in the field, would have seen an obvious benefit to the solutions tried by the patent applicant. When there is a design need or market pressure to solve a problem and there are a finite number of

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identified, predictable solutions, it would have been obvious to a POSITA to try the known options. If a technique has been used to improve one device, and a POSITA would recognize that it would improve similar devices in the same way, then using the technique would have been obvious.

23. I understand that I do not need to look for precise teachings in the prior art directed to the subject matter of the claimed invention. I understand that I may consider the inferences and creative steps that a POSITA would have employed in reviewing the prior art at the time of the invention. For example, if the claimed invention combines elements that were known in the prior art and if the combination yields results that were predictable to a POSITA at the time of the invention, then this would make it more likely that the claim was obvious. On the other hand, if the combination of known elements yields unexpected or unpredictable results, or if the prior art teaches away from combining the known elements, then this would make it more likely that the claim that successfully combined those elements was not obvious. I understand that hindsight must not be used when comparing the prior art to the invention during an obviousness analysis.

24. I understand that obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the patented invention. Obviousness may also be shown by demonstrating that it would have been obvious to combine the teachings of more than one item of prior

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art. I understand that a claimed invention may be obvious if some teaching, suggestion, or motivation exists that would have led a POSITA to combine the invalidating references. I also understand that this suggestion or motivation may come from sources such as explicit statements in the prior art, or from the knowledge of a person having ordinary skill in the art. Alternatively, any need or problem known in the field at the time and addressed by the patent may provide a reason for combining elements of the prior art. I also understand that when there is a design need or market pressure, and there are a finite number of predictable solutions, persons of ordinary skill may be motivated to apply both their skill and common sense in trying to combine the known options in order to solve the problem.

25. I understand that absent evidence of an invention date prior to the filing date of a patent, the invention date of the patent is presumed to be its filing date. A prior invention requires a complete conception of the invention and a reduction to practice of that invention. The patent owner has the burden of establishing by clear and convincing evidence a date of conception earlier than the filing date of the patent.

V. Person of Ordinary Skill in the Art

26. I have been asked to identify the level of skill in the art pertinent to the '142 patent. It is my opinion that a person of ordinary skill in the art pertinent to the '142 patent would have had a bachelor's degree in electrical engineering, computer

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engineering, or similar discipline and had two years of experience with optical communications and networks. A person with a different degree but with additional relevant experience could still qualify if the additional experience compensates for the different educational background.

27. All of the opinions I express in this Declaration have been made from the standpoint of a person of ordinary skill in the relevant art at the time of the invention of the ’142 patent, which I am informed is, for purposes of this matter, the earliest claimed priority date of August 2, 2012. I consider myself a person of ordinary skill in the art as of no later than the earliest claimed priority date.

VI. Summary of Opinions

28. I have been asked to consider whether the claims of the ’142 patent are obvious over certain prior art references. As explained in detail in the following sections, it is my opinion that:

29. **Ground 1**: Claims 1-9 are rendered obvious by Ahn (Ex. 1015) in view of G.984.1 (Ex. 1011), G.984.3 (Ex. 1013), and RFC 4364 (Ex. 1014).

30. **Ground 2**: Claims 4 and 7 are rendered obvious by Ahn in view of G.984.1, G.984.3, RFC 4364, and BCM56685 (Ex. 1020).

31. **Ground 3**: Claims 1-9 are rendered obvious by G.984.1 in view of G.984.3, RFC 4364, and Ravindran (Ex. 1016).

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32. **Ground 4:** Claims 4 and 7 are rendered obvious by G.984.1 in view of G.984.3, RFC 4364, Ravindran and BCM56685.

VII. Technical Background

33. In this technical background, I describe the pertinent technology as it existed as of August 2012, the assumed priority date of the '142 patent.

34. The '142 patent "relates to computer networks and more particularly to optical data network traffic routing to multiple users in a local area." Ex. 1001 ('142 patent), 1:23-25. Specifically, the '142 patent claims "[a] digital data network communication method" over a passive optical network (PON) that includes virtually separating at least one private data stream intended for at least one private user device using an independently unique virtual routing table. *Id.* at cl. 1.

35. As I will describe, all these ideas were well known to a POSITA at the time of the alleged invention.

A. Passive Optical Networks

36. A Passive Optical Network (PON) is a fiber-optic telecommunications network that provides Ethernet connectivity from a main data source to endpoints. A fiber-optic network transmits information, in the form of pulses of light, from one location to another. The pulses of light, called signals, represent bits of data, such as voice, video, or computer data. Ex. 1017 (Liu) at 1:14-24. A PON, like many network types, is agnostic to the type or content of data passed through it.

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37. In contrast to active optical networks, a PON distributes a single signal to multiple branches, point-to-multipoint, through unpowered optical beam splitters. Ex. 1018 (Ramaswami) at 603-604, Figure 11.7. Instead of active devices in these locations, PONs use passive optical splitters. Ex. 1019 (Kramer) at 68.

38. PONs consist of a network-side interface at the main source, or head-end, and a client-side interface at the endpoints. Optical Line Termination (OLT) provides the network-side interface of the network while Optical Network Units (ONUs) provide the client-side or user-side interface.[1] Ex. 1013 (G.984.3) at 3, 7.

[1] G.984.3, and some other references, discuss both ONUs and Optical Network Terminations (ONTs). Both of these devices perform the same basic functions, including terminating fiber connections at the user's end, converting optical signals to electrical signals (and *vice versa*), and providing ethernet or other interfaces for connecting to user devices or routers (e.g., Wi-Fi routers, LAN routers, or the like). The differences between ONUs and ONTs can be attributed to context and placement. ONTs are a type of ONU that is located at the customer premises (such as a home or office), while an "ONU" can also describe equipment located at a shared location (e.g., a curbside cabinet or a multi-dwelling unit such as an apartment complex). For the sake of consistency, I will use the term "ONU" throughout this declaration, as it is the term used in the '142 Patent.

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39. PONs garnered popularity in the late 1990s and early 2000s because of their numerous benefits, such as their ability to convey significantly more information than conventional electrical cables. For example, an optical fiber operating at 10 Gb/s can carry data equivalent to over 128,000 voice calls. And dozens of fibers may be included in a single cable, thereby multiplying the amount of data that can be transmitted. Ex. 1007 (Liu) at 1:36-45. Because optical cables convey considerably more data than conventional electrical cables, fiber-optic networks are used to transmit large amounts of data across cities, states, and continents. *Id.* at 1:24-30.

40. Further, PONs allowed for long reach between central offices and customer premises, minimized fiber deployment, provided higher bandwidth, and eliminated the necessity to install active multiplexers at splitting locations, thus relieving network operators of the gruesome task of maintaining active curbside units and providing power to them. Ex. 1009 (Kramer) at 68.

41. To standardize communication networks and allow interoperability for equipment in PON networks, the ITU-T issued a series of recommendations including G.984.1-3. G.984.3 summarizes the content of this series of recommendations, explaining that they describe "characteristics of a passive optical network (PON) with the capability of transporting various services between the user-network interface and the service node interface." Ex. 1013, 9. Specifically, G.984.3

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describes a gigabit-capable passive optical network (GPON), which is a "variant of the passive optical network (PON) access technology supporting transmission rates in excess of 1 Gbit/s and based on the G.984-series of ITU-T Recommendations." *Id.*, 11.

42. G.984.1 and G.984.3 further discloses components of the GPON network, including an optical line termination (OLT), an optical network unit (ONU), and an optical network termination (ONT). *Id.* These are shown in Figure 2 of G.984.1, reproduced below. Ex. 1011, 12.

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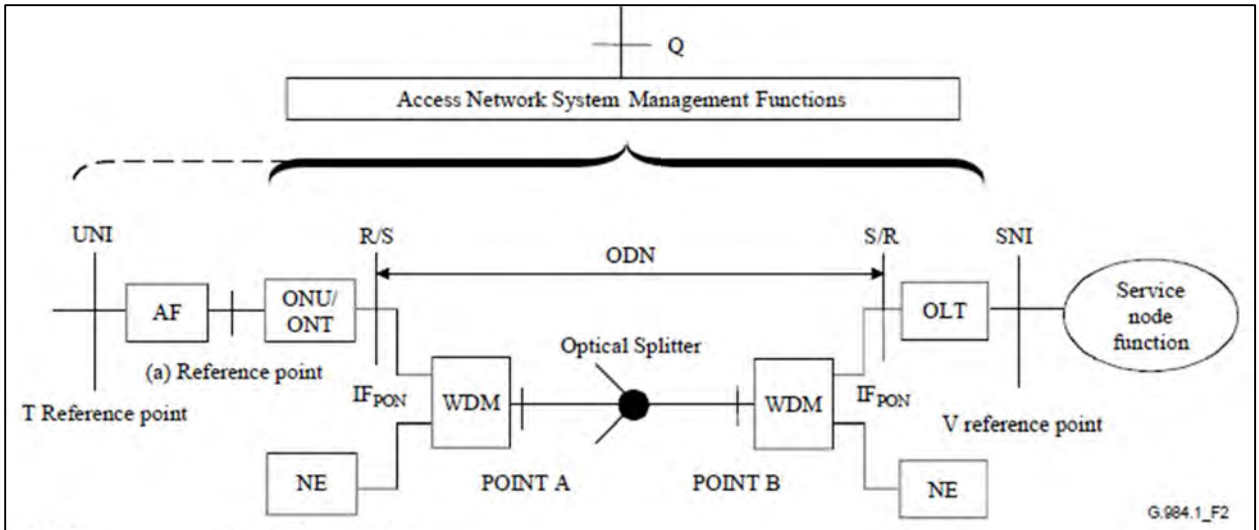

ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

B. Virtual Private Networks (VPNs)

43. While PONs form part of the physical medium used for transmitting data over the Internet, Virtual Private Networks (VPNs) provide a form of privacy for data transmitted over the Internet, regardless of the physical or logical medium used for connecting end points. A VPN includes a plurality of network end devices that can privately communicate with one another, even if those devices are not

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physically proximate to one another and/or physically connected with one another on a Local Area Network (LAN).

44. VPN services have evolved from subscriber-based VPN technologies including IPsec, PPTP, or L2TP to encompass, among others, MPLS-based VPN services at Layer 2 and Layer 3 to enable "tunneling," whereby information can be transmitted across an IP network "backbone" (such as the internet) through known routers to different end points that are connected to the same private network, while maintaining security against unauthorized viewing of data by user devices outside of the private network. These technologies have been known for years and have developed their own standards for implementation. Additional new control plane technologies have been also developed over time, including EVPN, which provide the same support for L2 and L3 VPN services.

45. In MPLS-based VPN services, provider edge devices connect customer devices (e.g., hosts, L2 switches, or IP routers) with a public data network. Those provider edge devices only service the customer devices that are connected to it, and so when those provider edge devices operate as routers for L3 BGP/MPLS VPNs, they maintain only routing information relevant for the connected customer devices—not routing information for all customer devices connected to a VPN across the public network. The routing information is stored in VPN Routing and Forwarding (or Virtual Routing and Forwarding) tables known as "VRFs"). VRFs

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are not required for user devices to connect to a network (e.g., the internet). Those provider edge devices can, and often do, have "global" routing tables for connecting devices outside of the VPNs to the network.

46. When data is transmitted across the public network using an MPLS-based VPN, the data packet is encapsulated and given a MPLS label that is used to determine the appropriate provider edge device to receive the data so that it can be provided to its intended recipient customer device. As mentioned above, the provider edge device can service multiple customer devices that may have overlapping IP address spaces, and the MPLS label ensures that these overlapping IP address spaces can be maintained separately. In effect, the MPLS label distinguishes the different customer devices serviced by provider edge device. Once received at the provider edge device, the MPLS label is removed and the data is forwarded to the customer device. In networks where data is visible to multiple customer devices, each data packet is labeled with its intended recipient (so that the customer device knows to discard any data packets having different labels), and the data may be encrypted using an encryption key shared between the provider edge device and the customer device, so that only the intended recipient customer device can decrypt the data packets.

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VIII. The ’142 Patent

47. The ’142 patent “relates to computer networks and more particularly to optical data network traffic routing to multiple users in a local area.” Ex. 1001, 1:23-25. Specifically, the ’142 patent claims “[a] digital data network communication method” over a passive optical network (PON) that includes virtually separating at least one private data stream intended for at least one private user device using an independently unique virtual routing table. *Id.* at cl. 1.

48. The ’142 patent explains that Passive Optical Networks (PONs) provide increased bandwidth with less power consumption than historical copper wire used for digital data connectivity. Ex. 1001, 1:57-67. The increased data speeds provided by optical networks has led to network designs wherein one network router can distribute data to a multiplicity of end users through an OLT, which can eliminate the need for separate routers dedicated to each end user. *Id*., 2:4-13. However, according to the ’142 patent, “this creates an increased cyber-security risk for all those users connected to the PON interface routers since the global routing table can be surreptitiously accessed by a nefarious user, or by some cyber-entity mimicking a user on the PON.” *Id*.

49. The ’142 patent explains that the claimed method “can supply a multi-tenant site such as an office building 100 with converged voice, data and video signal content traffic at gigabit speeds to a plurality of mutually secure end point users such

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as building tenants having multiple end user devices such as computers, access points and wireless controllers, application servers and printers, and television sets." *Id*., 3:62-4:4. The '142 patent explains that the system uses "standards-based technologies that are designed and implemented to provide a point-to-multipoint networking through a single aggregation switch." *Id*., 4:14-18. The technology provides services to end users, such as telecommunication services including "Internet, public switched telephone networks, and broadcast/cable television 108, 110, 112." *Id*., 4:23-26. The multi-tenant LAN architecture includes a PON (also referred to as a "single premise router" or a "PON interface router" as recited in the claims), and "an aggregation switch referred to as an Optical Line Terminal (OLT)." *Id*., 4:34-44. Figure 2, shown below, illustrates services provided by multiple carriers for multiple tenants.

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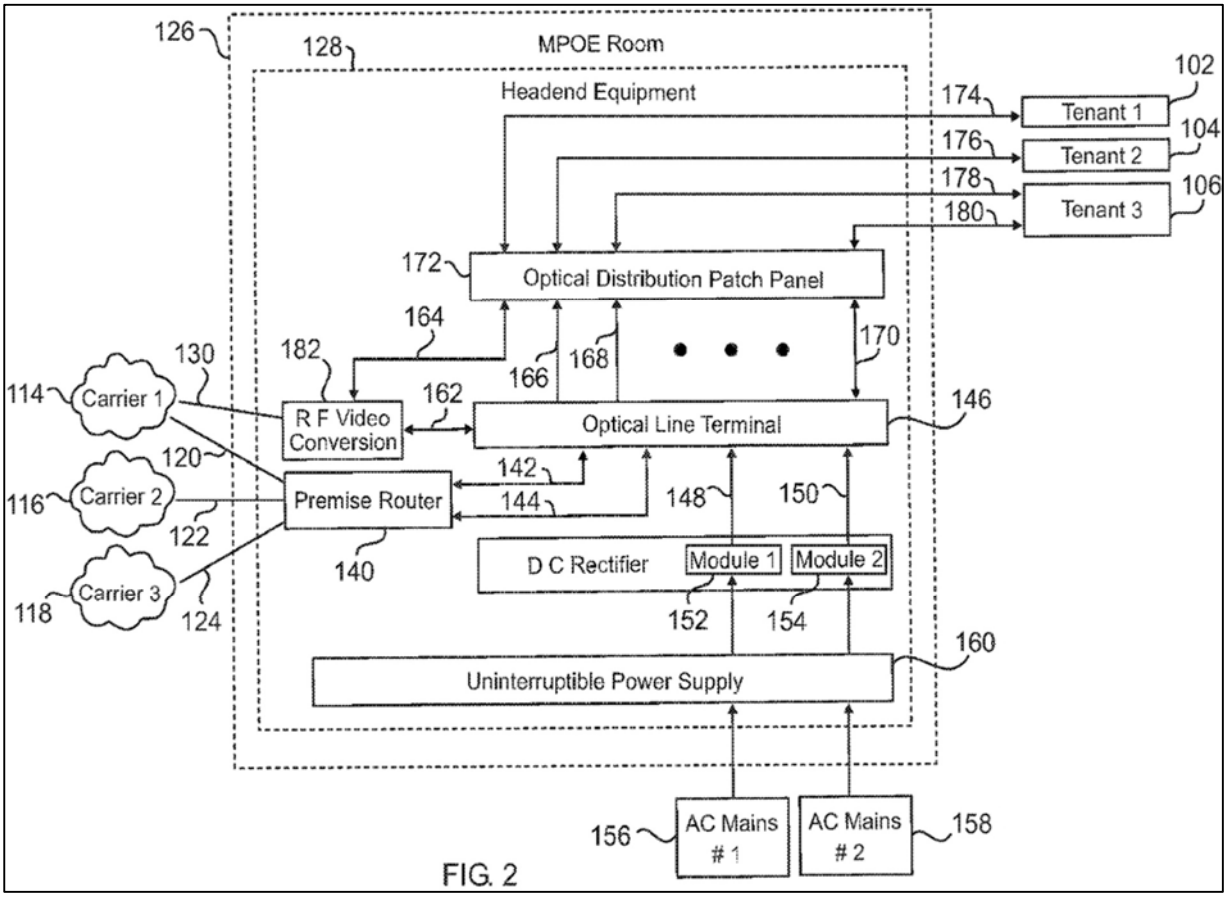

FIG. 2

50. As mentioned previously, the ’142 patent explains that standards-based technologies are used for security, and specifically the premise router “can be configured with Virtual Routing and Forwarding (VRF) as described in RFC 4381 and RFC 4382 and utilizes Virtual Local Area Network (VLAN) tagging to “separate and manage the distribution of the voice, video and data content traffic to each of the users.” *Id*., 4:52-59. By using VRF, each connected user (using an ONU) has its own VLAN, and consequently each user can have an independent IP address space (with overlapping IP addresses between different users with different ONUs that

have different VRF tables at the OLT), despite the OLT sending data for multiple ONUs in an aggregated data feed over an optical line.

51. Figure 3 (reproduced below) shows a premise router interfaced with commercial carrier providers to utilize telecommunications services provided over carrier lines.

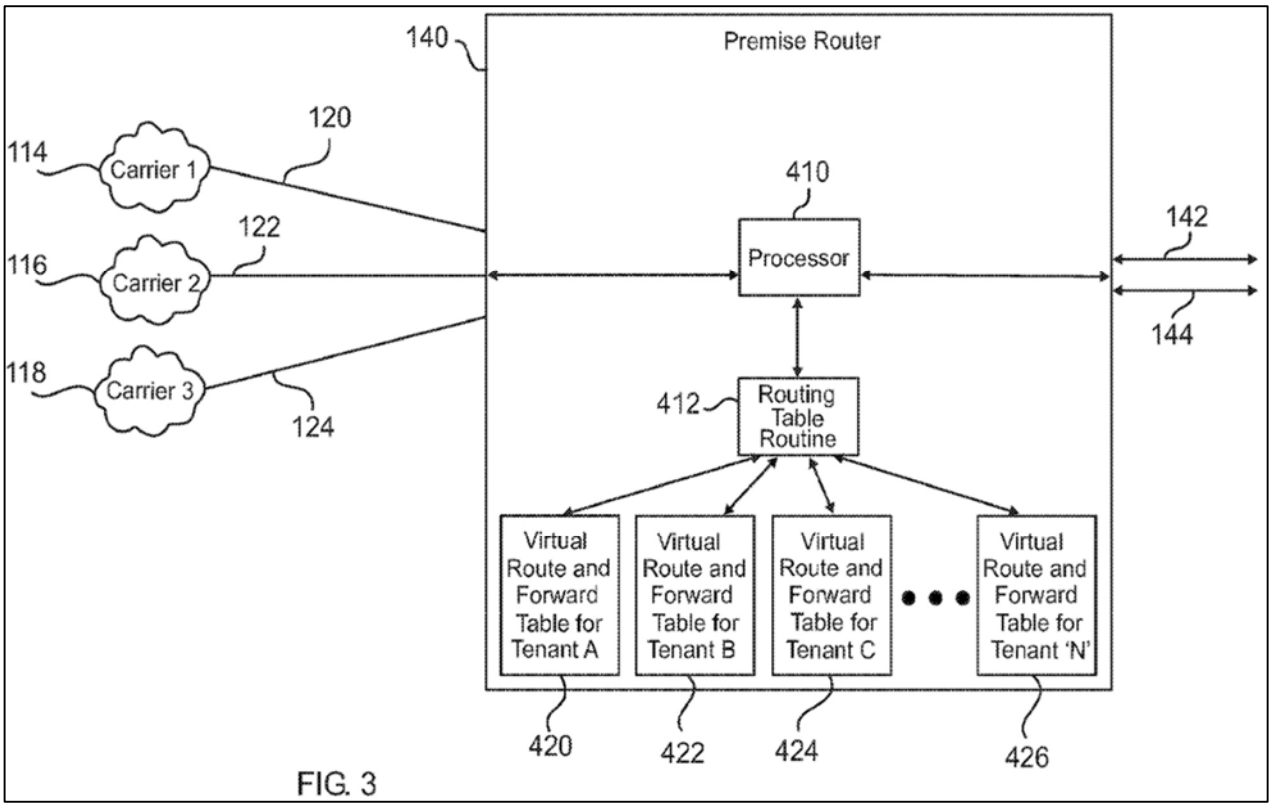

FIG. 3

52. As shown in Figure 3, the premise router "can be configured to run a routing table routine 412 that accesses the virtual routing table instantiations to create virtual routing tables 420, 422, 424, 426 for each Optical Network Unit (ONU) serving a tenant." *Id.*, 5:42-52. This allows for creation of multiple routing tables – one for each ONU, so that the premise router can support the overlapping

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of IP addresses for any of the tenants because each tenant has an independent routing space, and so that "data traffic intended for one tenant is automatically isolated from traffic intended for other tenants." *Id*. The created routing tables are used to uniquely tag the service content sent and received from the various ONUs, through the OLT, to the premise router. *Id*., 5:58-64.

53. The following pseudo-code (with line numbers matching Column 6 of the '142 patent) illustrates the functionality that the '142 patent envisions for the premise router providing services to multiple tenants via their respective ONUs.

[11] !---Begin gateway configuration and programming

[12] !---Configure gateway identity

[13] !---Establish express forwarding to optimize network per-

[14] formance and scalability

[15] !---For each tenant (1 . . . n) Do

[16] !---Instantiate virtual route table for the Tenant

[17] !---Enable VPN (Virtual Private Network) for the Tenant

[18] !---Establish routing and forwarding for the virtual rout-

[19] ing table

[20] !---Creates lists of import and export route-target

[21] extended communities

[22] !---End Do

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[23] !---Set IP (Internet Protocol) address, netmask and enable

[24] IS-IS routing

[25] !---For each tenant (1 . . . n) Do

[26] !---Establish loopback identifier for the Tenant

[27] !---Enable VRF (Virtual Routing and Forwarding) for the

[28] Tenant

[29] !---Associate the VRF instance with an interface or sub-

[30] interface.

[31] !---Loopbacks use the same IP address because they

[32] belong to different Tenant VRF's

[33] !---Broadcast to all hosts on the subnet

[34] !---End Do

[35] !---Define and configure the gateway ingress interface

[36] !---Set bandwidth

[37] !---Config IP address and netmask

[38] !---Enable MPLS (MultiProtocol Label Switching)

[39] !---Enables logging of BGP (Border Gateway Protocol)

[40] neighbor resets.

[41] !---Adds an entry to the BGP or multiprotocol BGP

[42] neighbor table

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[43] !---Enables BGP sessions to use a specific operational

[44] interface for TCP (Transmission Control Protocol) con-

[45] nections

[46] !---Enter address family configuration mode

[47] !---Sends the community attribute to a BGP neighbor

[48] !---For each tenant (1 . . . n) Do

[49] !---Set the address family for the tenant

[50] !---End Do

[51] !---Use longest prefix matching or default route

[52] !---end gateway configuration and programming

Id., 6:11-52.

54. Figure 4 (shown below) shows the PON infrastructure for distributing data packets for providing services to ONUs. As shown, data packets for each tenant are aggregated into a common data feed and then sent to an optical splitter that provides the same data feed to ONUs for each of the tenants. *Id*., 7:1-21.[2] Each ONU

[2] While the claims use the term "data package," the specification does not use this term, and instead uses the term "data packets" in a similar context. The references I discuss herein also use the terms "data packages" and "data packets" to refer to the same concepts, and so I use these terms interchangeably in this declaration.

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uses the VLAN-tagging to select those of the incoming ethernet frames assigned to the particular tenant, and then removes the encryption from the selected ethernet frames. Thus, each ONU strips out or extracts only those incoming frames that are intend [*sic*] for the particular tenant." *Id*., 7:22-27. Those decrypted/extracted frames are then made available for the tenant's IP/ethernet end-user equipment. *Id*.

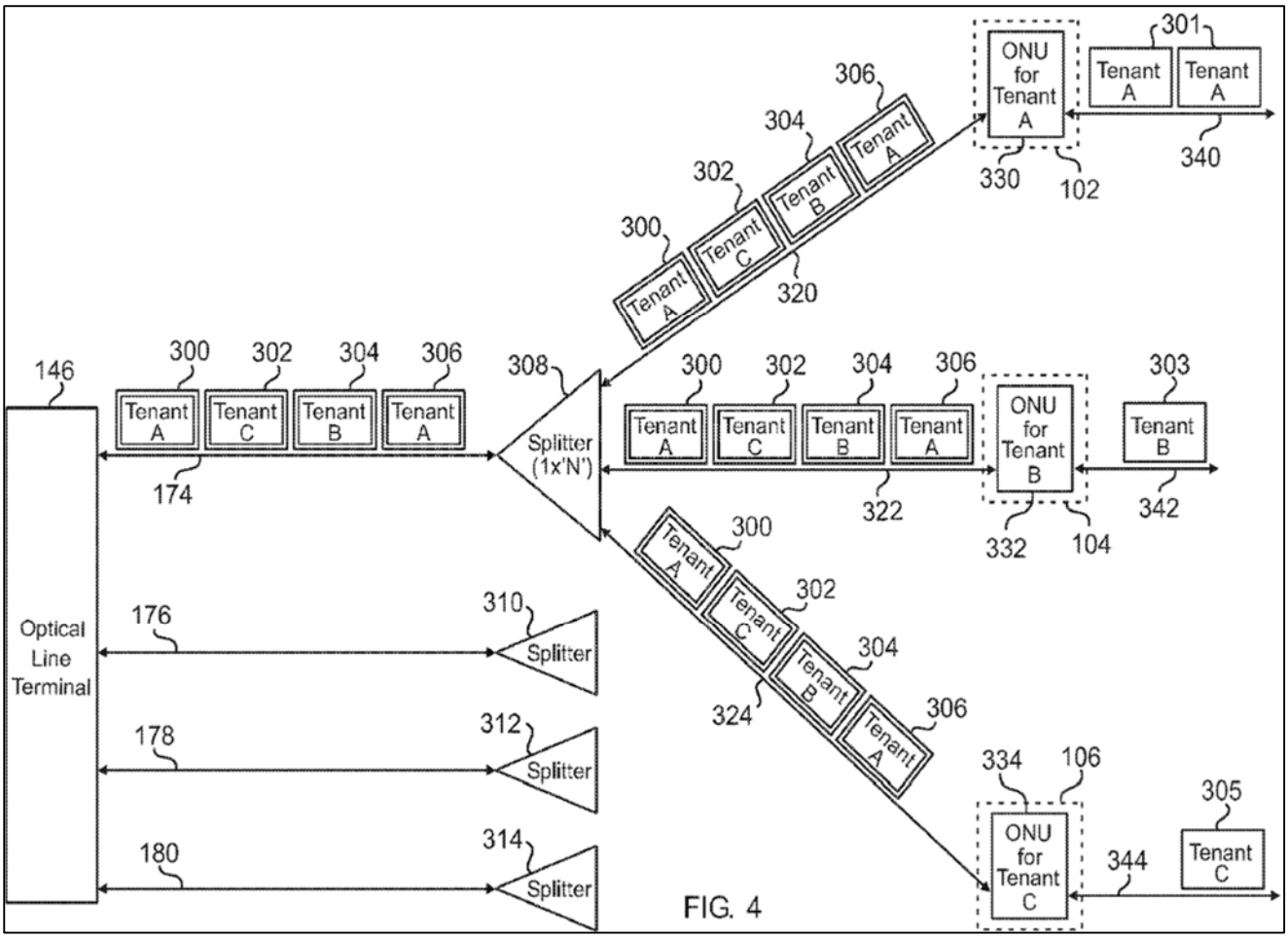

FIG. 4

55. I understand the filing date of U.S. Provisional Application No. 61/678,977, to which the '142 patent claims priority, is August 2, 2012. Ex. 1001.

56. The claims of the ’142 patent that are being challenged, and that I have been asked to evaluate, are claims 1-9. I have reproduced the challenged claims below:

Claim	Recitation
[1.PRE]	A digital data network communication method comprises:
[1.A]	accepting a plurality of data streams into a primary passive optical network (PON) interface router, interconnected with a secondary PON interface router serving a plurality of user devices through a plurality of optical network units (ONUs);
[1.B]	configuring said primary PON interface router to virtually separate the information intended for at least one private user device of a plurality of user devices, wherein said at least one private user device of a plurality of user devices is connected to at least one of said plurality of ONUs;
[1.C]	wherein said configuring comprises:
[1.D]	generating at least one independently unique virtual routing table by using Virtual Routing and Forwarding (VRF);
[1.E]	virtually separating at least one private data stream intended for said at least one private user device from said plurality of data streams using said at least one independently unique virtual routing table to create at least one virtually separated private data stream containing Internet Protocol (IP) data packages;
[1.F]	uniquely labelling said IP data packages contained in said at least one virtually separated private data stream using Multi-Protocol Label Switching (MPLS) to create MPLS labelled data packages;
[1.G]	sending said plurality of data streams, including said at least one virtually separated private data stream comprising said MPLS labelled data packages, to said secondary PON interface router;
[1.H]	receiving said plurality of data streams including said at least one virtually separated private data stream at said secondary PON interface router;
[1.I]	converting said MPLS labelled data packages contained within said at least one virtually separated private data stream back to said IP data packages;

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Claim	Recitation
[1.J]	forwarding said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages from said secondary PON interface router to a PON optical line terminal (OLT);
[1.K]	aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;
[1.L]	distributing said common data feed to said plurality of ONUs;
[1.M]	wherein said distributing comprises:
[1.N]	replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;
[1.O]	delivering said common data feed to said plurality of ONUs;
[1.P]	extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;
[1.Q]	sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.
[2]	The method of claim 1, wherein said at least one of said plurality of ONUs provides services to at least one private user a of plurality of users.
[3]	The method of claim 1, wherein said secondary PON interface router is serially connected to at least one additional PON interface router that is serially connected to said PON OLT, wherein said least one additional PON interface router delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.
[4]	The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.
[5.PRE]	A digital network communication method comprises:

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Claim	Recitation
[5.A]	receiving from at least one passive optical network (PON) interface router out of a plurality of PON interface routers at a PON optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices;
[5.B]	aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;
[5.C]	distributing said common data feed to said plurality of ONUs;
[5.D]	wherein said distributing comprises:
[5.E]	replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;
[5.F]	delivering said common data feed to said plurality of ONUs;
[5.G]	extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;
[5.H]	sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.
[6]	The method of claim 5, wherein said at least one of said plurality of ONUs provides services to at least one private user of a plurality of users.
[7]	The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream comprising said IP data packages to said PON OLT.

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Claim	Recitation
[8.PRE]	A digital network communication method comprises:
[8.A]	receiving at a passive optical network (PON) optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices;
[8.B]	aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;
[8.C]	distributing said common data feed to said plurality of ONUs;
[8.D]	wherein said distributing comprises:
[8.E]	replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;
[8.F]	delivering said common data feed to said plurality of ONUs;
[8.G]	extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;
[8.H]	sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.
[9]	The method of claim 8, wherein said at least one of said plurality of ONUs provides services to at least one private user our of plurality of users.

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IX. Prosecution History

A. U.S. Patent Application No. 17/377,223

57. U.S. Patent Application No. 17/377,223 (the "'223 Application"), which matured into the '142 patent, was filed on July 15, 2021. Ex. 1001. The '223 Application was filed claiming priority back to U.S. Provisional Patent Application No. 61/678,997, filed on August 2, 2012, through a series of continuation, continuation-in-part, and national stage filings.

58. The '223 Application was filed with three claims. Ex. 1004 ('142 FH) at 35-36.

59. On October 26, 2022, there was a telephonic interview, during which the Applicant proposed replacing the three originally filed claims with new claims 4-12. *Id*., 64. The Applicant also filed a terminal disclaimer on October 25, 2022, over Pat. No. 11,070,898. *Id*., 44. The case was subsequently allowed, and a Notice of Allowance was mailed on January 13, 2023. *Id*., 50. In the Notice of Allowance, the Examiner included an Examiner's Amendment to replace the originally filed claims 1-3 with new claims 4-12. *Id*., 55-60. The Examiner stated that these claims are allowable "for similar reasons as parent Application 17/128,042, filed 12/19/2020, now U.S. Patent # 11,070,898." *Id*., 61. According to the Examiner, "Applicant's inventive steps [] disclose novel method [*sic*] for its distribution and replication of a feed in an optical network, which is not disclosed by conventional

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methods which pertain to optical networks. Such us [*sic*] conventional methods do no[t] use the virtual routing and forwarding in the same way as the [claims]." *Id*., 62.

B. U.S. Patent Application No. 17/128,042

60. U.S. Patent Application No. 17/128,042 (the "'042 Application"), which matured into U.S. Patent No. 11,070,898, was filed on December 19, 2020. Ex. 1005 ('042 FH), 1. As mentioned above, the '223 Application claimed priority to the '042 Application as a part of the priority claim back to the originally filed U.S. Provisional Patent Application No. 61/678,997, filed on August 2, 2012.

61. The '042 Application was filed with three claims (the same three claims that were originally filed in the '223 Application). *Id.*, 30-31.

62. A first, non-final office action was mailed on March 9, 2021. *Id*., 50. The Office Action included a non-statutory double patenting rejection over U.S. Patent No. 10,904,649 (*Id*., 52-54), and a rejection under 35 U.S.C. § 101 (*Id*., 55).

63. The Applicant filed a response on May 18, 2021, which included claim amendments. The amendments to independent claim 1 are reproduced below.

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1. (Currently Amended) A ~~multi-user optical data network apparatus~~ digital data network communication method comprises:

accepting ~~at least one private data stream of~~ a plurality of data streams into ~~at least one~~ a passive optical network (PON) interface router, interconnected with at least one secondary PON interface router serving a plurality of ~~private~~ user devices through a plurality of optical network units (ONUs);

configuring said ~~at least one~~ PON ~~passive optical network~~ interface router to virtually separate the information intended for at least one of ~~said~~ a plurality of private user devices, wherein said at least one of a plurality of private user devices is connected to at least one of said plurality of ONUs;

wherein said configuring comprises:

generating ~~an~~ at least one independently unique virtual routing table ~~for said at least one of said plurality of private user devices~~ by using Virtual Routing and Forwarding (VRF);

virtually separating at least one private data stream intended for said at least one private user device from said plurality of data streams using said at least one independently unique virtual routing table to create at least one virtually separated private data stream;

uniquely ~~tagging~~ labelling ~~the ethernet frames~~ Multi-Protocol Label Switching (MPLS) data packages contained in said at least one virtually separated private data stream ~~and intended for said at least one of said plurality of user devices according to the entries of said virtual routing table associated with said at least one private user device~~ using ~~Multi-Protocol Label Switching~~ (MPLS), ~~to form MPLS data packets~~ whereby said MPLS data packages are further identified as MPLS labelled data packages;

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sending said plurality of data streams, including said at least one virtually separated private data stream comprising said MPLS ~~tagged~~ labelled data packages, to the said at least one secondary PON interface router ~~a passive optical networks optical line terminal (OLT)~~;

forwarding said plurality of data streams including said at least one virtual separated private data stream from said at least one secondary PON interface router to a PON optical line terminal (OLT) without altering the virtual separation of said at least one virtually separated private data stream and without altering said MPLS labelled data packages;

aggregating within said OLT said ~~MPLS tagged data packages~~ plurality of data streams and said at least one virtually separated private data stream into a common data feed ~~that also contains ethernet frames without MPLS tags~~;

distributing said common data feed to said plurality of ONUs;

wherein said distributing comprises:

replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;

~~extracting from said common data feed said MPLS tagged data packages intended for said at least one private user device.~~

delivering said common data feed to said plurality of ONUs;

extracting~~, from~~ within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including ~~those~~ said MPLS ~~tagged~~ labelled data packages ~~intended for said at least of said plurality of private user devices~~ from said common data feed~~,~~;

sending said at least one virtually separated private data stream including said MPLS labelled data packages from said at least one of said plurality of ONUs to said at least one of a plurality of private user devices.

Id., 75-76.

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64. The response also included an information disclosure statement, and arguments discussing the contents of the references cited in the IDS. The discussion of those cited references is reproduced below, showing the Applicant was aware of PON and MPLS technologies used together before the priority date of the '042 Application. *Id*., 79-81. The Applicant also filed a terminal disclaimer to overcome the outstanding non-statutory double patenting rejection. *Id*., 82.

PATENTS

Vasseur Patent – 8199642 - This patent relates to tunneling of IP packets inside an MPLS cloud core network and its related MPLS label changes. It does not make any reference to PON.

Zheng Patent – 8565597 - This patent relates to the creation of a unique PON based MPLS scheme for Mobile Base Station Applications as well as the set up and use of an ONT as a router to interact with the OLT in the creation and management of these MPLS labelled packets.

Zheng Patent Application – 20110116796 – This patent application attempts to resolve the problem of protocol stack layer complications when a PON is coupled with mobile network. The instant invention points the fact that the PON in its native form causes that problem with the way it handles the MPLS packets. The inventor seeks to solve the problem by suggesting encapsulating the MPLS packages immediately at the OLT via the GPON encapsulation method (GEM) and maintaining them encapsulated all the way to the ONUs where the decapsulation occurs and the packets are returned to their original MPLS state.

Schmidtke Patent – EP 215754 A1 – This patent relates to a suggested GPON system used as router with its related virtual routing functionality. There is no mention of MPLS or VRF.

NON-PATENT PUBLICATIONS

TOM RARICK and TIM DOIRON, MPLS and GPON: Happy together in the next-generation OLT, Lightwave On Line, 2007-02-06, United States -This publication relates to a concept similar to that described in the Zheng patent (8565597) and the Schmidtke

Patent (EP 215754 A1) both of which propose the use of a PON OLT in a routing and switching capacity and with it, its capacity to produce and manipulate MPLS labels.

CABLE TELEVISION LABORATORIES, INC, Converged Access Platform Architecture Technical Report, 2011-06-14, United States of America –This publication defines the way to use EPON as a method of transport of DOCSIS (RF transported IP information). Within this particular method the PON Optical Line Terminal is completely bypassed and only its functionality to turn on the laser of its ports is used. This is termed as an overlay of DOCSIS over the EPON system, and it is accomplished by amplifying the DOCSIS RF signal with an Erbium Doped Fiber Amplifier (EDFA) and inserting it as an optical beam operating in the 1550 nanometer band immediately after the OLT and before the splitters via a Wave Division Multiplexer (WDM). This 1550 optical beam is them sent via the splitters to the ONUs. Only the ONUs within a network that are equipped with appropriate Optical to RF converter will be able to receive the optical signal and convert it to the appropriate DOCSIS RF format. Once that is accomplished, the DOCSIS signal is sent to the setup box of the end user.

FUJITSU NETWORKS COMMUNICATIONS, INC, How GPON Deployment Drives the Evolution of the Packet-Based Networks, Year 2007, United States of America, 9 Pages – This publication discusses the use of MPLS within a Layer 2 environment as applied to Pseudowire (PW). The MPLS labeling scheme used for Pseudowire is defined by a specific standard and PW is a point to point communications application that does not use fiber optic splitters.

ROUBIN ZHENG and HONGYU LI, Multi-segment Pseudowire in Passive Optical Networks slide presentation, 2011, China, 8 slides – This publication discusses the use of MPLS as it applies to Pseudowire (PW) within a Layer 2 VPN environment.

ALCATEL-LUCENT, 7302 Intelligent Services Access Manager (7302 ISAM) and 7330 Intelligent Services Access Manager Fiber to the Node (7330 ISAM FTTN), 598 pages, United States – This publication describes a multi services rack that amongst the services supported includes EPON and GPON. The PON systems rely on point to point communication and therefore their OLTs are not required to aggregate data streams specifically intended to be sent to optical splitters. These systems support Layer 2 VPN including point to point ATM as well as point to point Pseudowire with its related MPLS scheme. The term VRF is depicted in three fairly cryptic images primarily related to router to router transport of Layer 2 VLANs within pages of the Routing section of this voluminous product specification. The VRF functionality is not textually described in the specification nor architecturally connected to PON in a meaningful way. The sections are well labelled and the reading is informative relative to its Layer 2 transport, support and capabilities.

None of the above patents, patent applications or publications alone or together suggest the combination required by the pending claims. The present involves Layer 3 mode of virtual information separation rather than to Layer 2 virtual information separation modes such as Frame Relay (Pseudowire (PW)), Asynchronous Transfer

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Mode (ATM), Ethernet, High Level Data Link Control (HDLC), or Point to Point Protocol (PPP).

Applicant reserves the right to prosecute any cancelled claims or any other broad claims supported by the original disclosure in one of more continuing applications.

Id., 79-81.

65. On June 11, 2021, a Notice of Allowance was mailed indicating that the claims were allowable. *Id*., 99-104. The Examiner's reasons for allowance were identical to those discussed for the '223 Application, with the exception that the recited claim language matched the claims of the '042 Application.

C. U.S. Patent Application No. 17/600,302

66. U.S. Patent Application No. 17/600,302 (the "'302 Application"), which matured into U.S. Patent No. 10,904,649, was filed on October 11, 2019. Ex. 1006, 2. The above-mentioned '042 Application claimed priority to the '302 Application as a part of the priority claim back to the originally filed U.S. Provisional Patent Application No. 61/678,997, filed on August 2, 2012.

67. The '302 Application was filed with 13 claims. *Id.*, 29-31.

68. On December 19, 2019, the USPTO mailed a First Action Interview Pilot Program Pre-Interview Communication, indicating that the originally filed claims would be rejected as obvious over U.S. Pat. Publ. No. 2002/0141421 ("Dupont") and U.S. Pat. Publ. No. 2008/0212598 ("Koli"). *Id*., 51-58.

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69. The Applicant submitted an interview request on January 17, 2020, and attached two declarations, signed by Joseph L. Vilella (the inventor), and Michael Zegarski, respectively. *Id*., 66-84.

70. Mr. Vilella's declaration explains how he conceived the idea of using VRF on a PON system after determining that PON was not suitable for legally separating information among multiple end users. *Id*., 70-71.

> I struggled to find a solution this problem. Out of desperation and thinking totally out of the box, I investigated using a process that was available but rarely used in copper networks, namely Virtual Routing and Forwarding (hereinafter "VRF") as a way of somehow creating discrete, separated virtual routers on the PON. Because of its rare, limiting and infrequent use, few people in the IT community clearly understood the VRF process. At that time, neither I nor my SPADA partner James Reynante, who was a Cisco certified IT professional that had worked for me at SAIC, had enough knowledge about the VRF mechanisms to know whether the process held any potential for success.

Id., 70.

71. Therefore, even the inventor, Mr. Vilella, recognized that VRF was used with other networking media.

72. Mr. Vilella's declaration continues by explaining their first test of VRF over PON:

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In or about the second quarter of 2012, SPADA enlisted the help of SAIC to program a router to virtually separate information using VRF and to send the specially tagged Ethernet frames through the PON OLT. Representing SAIC, Mr. Jay McGuerty broug an SAIC owned router to SPADA, and configured it to properly perform the virtual information separation using VRF. James R. Reynante prepared our PON OLT to receive the virtually separated information generated by the router and pass it via an optical splitter to two ONUs. If the information was received successfully in its entiret the capability of PON to accept and maintain legally separated information would have been proven. If the information would have been partially received (frames were missed), or not received at all, the process would have failed. In that case, SPADA

5

would have had to request that Motorola Mobility undertake the daunting task of adapting their OLT operational programming to try to accommodate the process.

The results were positive and the process of virtually separating information and accepting it in its entirety across the PON was a proven and replicable reality. Such a positive initial result was not generally expected.

Id., 71-72.

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73. Therefore, implementing VRF over PON simply required configuring a router and a PON OLT to perform virtual information separation and to receive virtually separated information, according to the already known VRF methods.[3] The first test was successful with little effort to combine these known technologies. The inventors did not have to "undertake the daunting task of adopting [an] OLT operational programming to try and accommodate the process." *Id*.

74. Mr. Vilella attached an email from Jay McGuerty that summarized the results of the above-mentioned test. *Id*., 80-81. That email stated that, prior to the above-mentioned test, existing Cisco routers were already capable of MPLS/VRF, and that Motorola believed that these Cisco router features would work with GPON technology components. *Id*.

[3] As I discuss below, Broadcom was selling a commercial product that was already configured for this purpose. *See* Ex. 1020.

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Date: Monday, October 22, 2012 4:55 PM
To: Joseph Vilella <joseph.vilella@spadainnovations.com>, James Reynante <james.reynante@spadainnovations.com>
Subject: SPADA Multi-Tenant Solution Summary

Mr Vilella,

This is a summary of the multi-tenant testing SAIC performed at SPADA's lab in La Jolla.

SPADA was seeking a multi-tenant solution that provided secure isolation at layer-2 (VLAN) and Layer-3 (virtualized routing tables) up to and including an ISP cloud.

Cisco routers support Multi-Protocol Label Switching (MPLS)/Virtual Routing Forwarding (VRF) integrated with Border Gateway Protocol (BGP). These features used together can provide a secure multi-tenant network isolation solution.

The question was would these components work with the Motorolla's GPON technology. When Dr. Reynante contacted Motorolla regarding interoperability with Cisco MPLS/VRF their response was that they believed it would but that Motorolla had never tested this configuration.

SPADA contracted with SAIC to create a multi-tenant technology demonstrator solution consisting of two Cisco 2800's configured as an ISP cloud peering with BGP and four Cisco 2600's acting as tenant routers i.e. tenant "A" and tenant "B" at two physical sites.

A multi-tenant site-1 was created by connecting one of each tenant's routers to separate Motorolla ONT terminal in turn connected to a Motorola AXS1800. Each tenant router was configured with basic dynamic routing i.e. no special support for/knowledge of VRF, MPLS or BGP was required for customer premise equipment (CPE).

The Motorolla ONT terminals were configured to place each tenants traffic in different VLANs which were trunked transparently through the Motorolla AXS1800 to one side of the MPLS/VRF/BGP clould (Cisco 2800). The traffic was demonstrated to be isolated and not able to interact or have any knowledge of the other (note: this requires that only SPADA have administrative rights to the onsite ISP/clould router). Traffic from each tenant was observed to travel successfully to the other end of the clould (site-2 for tenant "A"

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and "B").

This demonstrates that the Motorolla AXS1800 successfully and transparently worked with the Cisco MPLS/VRF/BGP multi-tenant features. This was a small technology demonstrator but could be scaled up support much larger sites.

Additional development is required to provide a full suite of enterprise class services such as a high security caching DNS server, IDS/Firewall and Security Operations Center. Such an architecture could also support a multi-tenant VoIP solution as well.

v/r
--
Jay McGuerty
Principal Security Engineer
Science Application International Corporation

Id., 80-81.

75. The second declaration attached to this response was submitted by Michael Zegarski, an employee of Motorola Mobility, supporting its GPON technology division. *Id*., 82. Although the declaration suggests that Michael was skeptical of using VRF over GPON, Michael explains that VRF was an "information routing configuration," and he admitted that he did not understand how it was accomplished and tested. The relevant portion of Mr. Zegarski's declaration is reproduced below.

> Reason 2: The existence of a method by which information could be virtually and absolutely separated within a router was, to my knowledge, definitively not a mainstream routing set up process. Through my previous years supporting IT experts programming routers to interface with our OLTs, I had never heard or experienced the use of VRF-labeled Ethernet frames going through a layer-2 OLT. In my mind, VRF was a hardly used, very specialized and little known information routing configuration and as such, and without understanding how it was accomplished and tested, I was very skeptical that it would work with our OLT or any PON OLT for that matter.

Id., 83.

76. The Applicant submitted a reply on January 17, 2020, explaining that the two declarations mentioned above include evidence of secondary considerations of non-obviousness. *Id*., 88-90.

77. The Applicant submitted a supplemental response on March 9, 2020. *Id*., 95-101. The response included claim amendments (representative amendments to claim 1 are reproduced below), but did not include any substantive remarks. *Id*.

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In the Claims

1. (Currently Amended) A multi-user optical data network apparatus comprises:

at least one network service carrier line connected to a passive optical network interface router;

at least one uplink connecting said interface router to an optical line terminal;

said optical line terminal being connected to a number of passive optical network feeds for carrying a common data feed to a plurality of optical network units each supporting at least one of a plurality of private user devices;

said interface router being configured to have at least one virtual routing table for each one of said plurality of ~~optical network units~~ private user devices, whereby said common data feed comprises data packets uniquely tagged for each one of said plurality of private user devices; and,

wherein each of said optical network units is adapted to extract those of said data packets intended for a supported one of said private user devices, and ignore those of said data packets not intended for said supported one of said private user devices, thereby virtually isolating said private user devices from one another.

Id., 98.

78. The Applicant submitted a response to interview (the interview was conducted on July 13, 2020), on July 23, 2020, including a second declaration by Mr. Vilella that summarized VPN technologies commonly in use prior to 2012. *Id*., 104-106. Mr. Vilella discussed why capital investments in new equipment prevented the use of VPNs over PON, but does not discuss whether a POSITA would have recognized that VPNs were usable with PON network architectures.

79. On August 6, 2020, the Examiner mailed a First Action Interview Office Action Summary, indicating that the claims were rejected over Kolli, U.S.

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Pat. Publ. No. 2004/0223500 ("Suvakovic"), and U.S. Pat. No. 7,500,004 ("Homer"). *Id*., 109-111. The Applicant filed a response on October 6, 2020, amending the claims (representative amendments to claim 1 are shown below). *Id.* 122.

In the Claims

1. (Currently Amended) A multi-user optical data network apparatus comprises:

at least one network service carrier line connected to a passive optical network interface router;

at least one uplink connecting said interface router to an optical line terminal;

said optical line terminal being connected to a number of passive optical network feeds for carrying a common data feed to a plurality of optical network units each supporting at least one of a plurality of private user devices;

said interface router being configured using Virtual Routing and Forwarding (VRF) commands to have at least one virtual routing table for each one of said plurality of private user devices, whereby said common data feed comprises data packets uniquely tagged using Multi Protocol Label Switching (MPLS) for each one of said plurality of private user devices; and,

wherein each of said optical network units is adapted to extract those of said data packets intended for a supported one of said private user devices, and ignore those of said data packets not intended for said supported one of said private user devices, thereby virtually isolating said private user devices from one another.

Id., 123

80. The Applicant included remarks, that stated in relevant part:

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> The examiner suggests that because Kolli teaches the use of virtual routing tables, which applicant admits is known in the copper networking world, and Suvakovic teaches the use of routing tables by a PON, which applicant admits is well-known since that's what routers use, that somehow the combination of those two things is obvious. Applicant disagrees.

Id., 129.

81. Therefore, the Applicant admits that virtual routing tables and routing tables by a PON were both known. Applicant thus argues that a POSITA would not have combined these references, and suggests that the previously submitted declarations were sufficient to show secondary considerations of non-obviousness. *Id*., 130-131.

82. A final office action was mailed on October 8, 2020, indicating that pending claims 1, 4-6, and 13 were rejected as obvious over U.S. Pat. Publ. No. 2012/0128349 ("Mitsunaga") and U.S. Pat. No. 6,693,878 ("Daruwalla"). *Id*., 139. Claims 8 and 10-12 were allowed. *Id*., 145.

83. The Applicant responded on November 5, 2020, canceling all of the rejected claims. *Id*., 160-166.

84. A Notice of Allowance was mailed on November 30, 2020. *Id*., 168-175.

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D. Other Applications

85. The remaining applications filed as a part of the same family as the '142 patent were all filed as continuations-in-part and subsequently abandoned. These applications include: (1) U.S. Patent Application No. 16/431,602 (the "'602 Application") filed on June 4, 2019 (Ex. 1007 ('602 FH), 1), (2) U.S. Patent Application No. 15/351,315 (the "'315 Application") filed on November 14, 2016 (Ex. 1008 ('315 FH), 1), and (3) U.S. Patent Application No. 14/419,092, filed Aug. 2, 2012 (Ex. 1009 ('092 FH), 1). These applications all trace their priority claim back to the originally filed U.S. Provisional Patent Application No. 61/678,997, filed on August 2, 2012. Ex. 1010, *generally*.

86. The prosecution of these applications was unremarkable, and did not shed any light on the interpretation of the claims of the '142 patent.

X. Claim Construction

87. Based on my review of the '142 patent and its file history, a POSITA would have understood the claim terms in light of the specification, and interpreted them by using their plain and ordinary meaning in accordance with the then current state of the art. Therefore, I do not believe that any terms require an explicit construction.

88. Of note, the term "PON interface router" is not a term of art, and so its meaning in the claims is determined by how it is used in the '142 patent. The term

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has its plain-English meaning of the words in the phrase – a router that interfaces with a PON, enabling connection of signals received by the router to be transmitted to the PON. Ex. 1001, 4:34-61.

XI. Prior Art References

A. Shin-Young Ahn & Jae-Doo Huh, entitled "A Study on Ethernet-PON System functionality for L2/L2 MPLS based VPN service" ("Ahn;" Ex. 1015)

89. A "Study on Ethernet-PON system functionality for an L2/L3 MPLS-based VPN service" ("Ahn") was written by Shin-Young Ahn and Jae-Doo Huh of the Access Technology Research Division of the Electronics and Telecommunications Research Institute (ETRI). Ahn was published in November of 2002 as part of the 18th Korea Information Processing Society, Proceedings of the Autumn Academic Conference Vol. 9 No. 2. Ex. 1015, 1. Ahn was never cited during prosecution of the '142 patent. *See generally*, Ex. 1002. Between November 2002 (when Ahn was published) and August 2012 (the priority date of the '142 patent), South Korea was home to many companies developing PON-based technologies. This is demonstrated at least by the supports of the 10Gbps PHY for EPON Call for Interest, which lists South Korean companies including Corecess, ETRI, Korea Telecom, and Samsung Electronics as being involved in the development of PON technologies. Ex. 1023, 2. Therefore, a POSITA working in this technology field, particularly before the '142 patent priority date, would have

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sought out and found research papers presented at Korean conferences, and would have known to look for research papers published in the Korean Science database and/or through the Korean academic research publication services such as Naver and/or ScienceOn. *See* Ex. 1030, ¶ 64. Searching these databases in English would have identified relevant documents, including the Ahn publication, relevant to PON system functionality. *See* Ex. 1024 (the Korean publication included an English-language title). Therefore, a POSITA would have looked for publications and found the Ahn publication prior to the '142 patent priority date.

90. Ahn discusses "the functional requirements of Optical Network Units (ONU) and Optical Line Terminals (OLT) necessary to develop VPN technology for L2/L3 MPLS-based network subscribers on Ethernet-PON (E-PON)-based optical subscriber networks that are linked with an MPLS/IP backbone. Ex. 1015, 1.

91. Ahn explains that "the most widely deployed subscriber network solutions, Digital Subscriber Line (DSL) and cable modem networks are insufficient to meet the performance requirements of such services." *Id*. However, Ahn explains that PONs (Passive Optical Networks) have emerged as an alternative for subscriber network technology" to address the bandwidth challenges of DSL and other "existing" networks. *Id*. Ahn describes multiple PON variations that all would have been known to work with the described VPN technologies—ATM PON, Ethernet

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PON, and WDM-PON, but focuses on Ethernet PON for the remainder of the submission. *Id*.

92. Ahn's introduction then explains that "MPLS technology, which enables IP packet switching at layer 2, has facilitated the emergence of various types of VPN services." *Id*. Ahn then describes "the specific functional requirements for implementing VPN services within ONU/OLT [Optical Network Unit/Optical Line Terminal] subsystems, as well as the SLAs (Service Level Agreements) associated with L2/L3 MPLS-based VPN services." *Id*.

93. In describing Ethernet-PON-based optical subscriber network systems, Ahn explains that these systems "broadly comprise OLT subsystems, ONU or ONT (Optical Network Terminal) subsystems, and ODN (Optical Distribution Network)." Ahn's FIG. 1 (reproduced below) shows an example PON system. Ahn clarifies that the illustrated OLT system is at the Central Office and the ONU/ONT subsystems are located at the curb of subscriber locations. *Id*., 2. As shown below in the illustrated example PON, "optical signals are delivered by being split by optical splitters/couplers, depending on whether the direction of light is upstream or downstream." *Id*.

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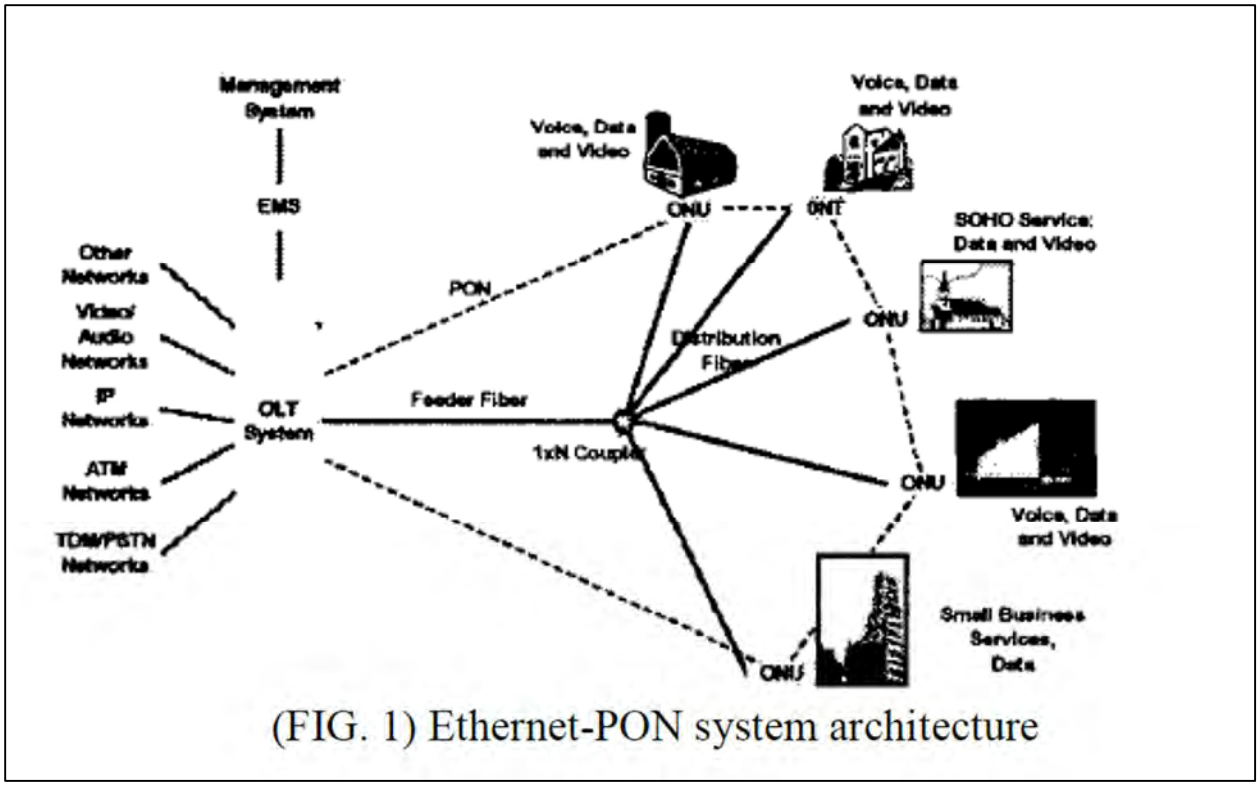
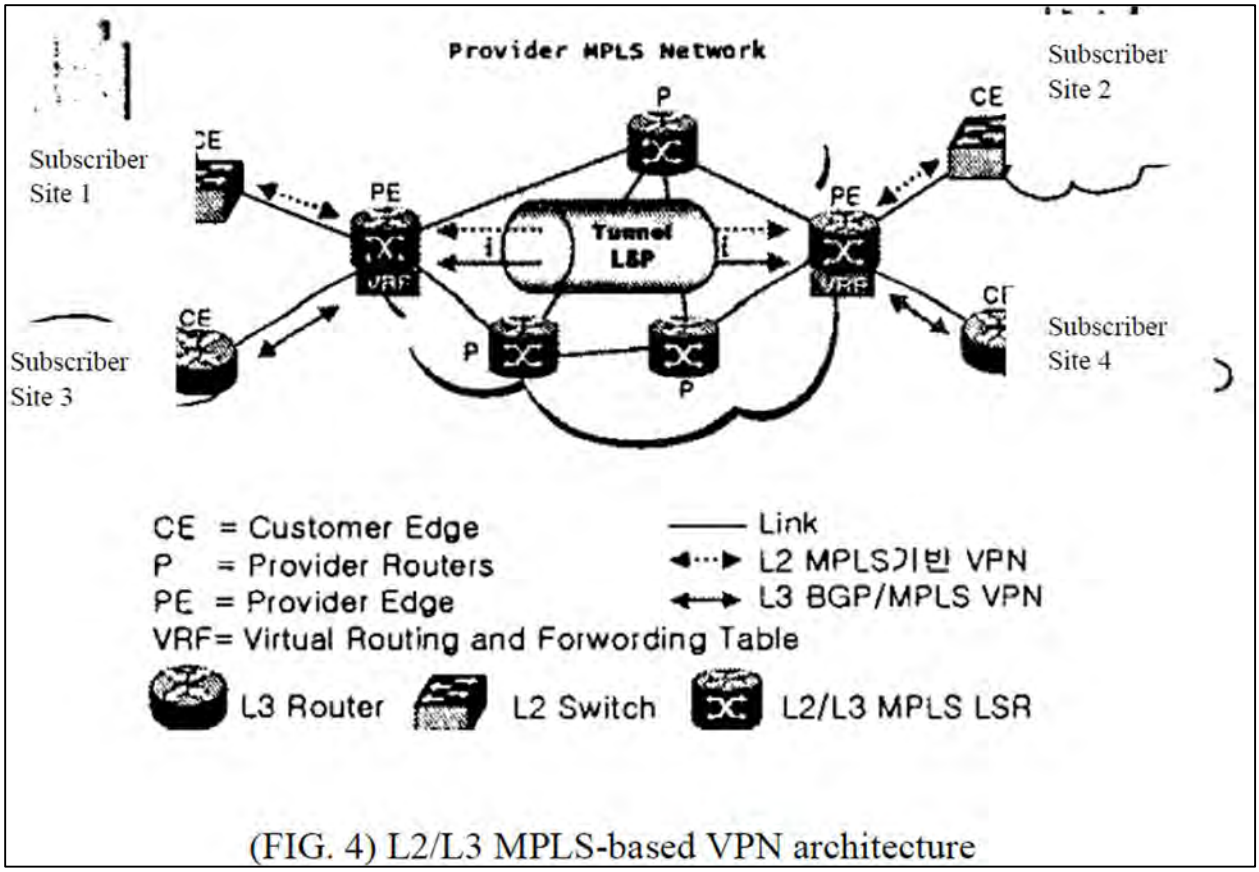


(FIG. 1) Ethernet-PON system architecture

94. With this basic background of the structure of a PON, Ahn then explains some basics of L2/L3 MPLS-based VPN technology. *Id*., 3. Ahn's explanation is agnostic as to the communication medium employed, so Ahn's explanation applies to DSL copper wire or any variation of PON systems. *Id*. Ahn explains that "VPN services over IP backbone networks have evolved through the adoption of MPLS technologies, into various VPN services provided by network operators. VPN technologies provided by network operators are categorized into L3 BGP/MPLS VPN technologies and L2 MPLS-based VPNs. *Id*., 3. Ahn's FIG. 4, reproduced below illustrates an example L2/L3 MPLS-based VPN architecture, where customer edge devices communicate with a network via a provider edge router having VRF tables corresponding to the customer edge devices.



(FIG. 4) L2/L3 MPLS-based VPN architecture

95. Lastly, Ahn describes VPN functionality in EPON systems. *Id*. "For L2/L3 MPLS-based VPNs, the initiation of service must be from a specific ONU port, which serves as the subscriber's access point. However, ONU does not operate as a system with upper-layer protocol capabilities, such as MPLS or routing protocols. Rather, ONU performs traffic multiplexing for subscribers. Such routing and MPLS edge functionalities are implemented at the OLT level." *Id*.

B. ITU-T Standard G.984 (G.984.1-3; Ex. 1010-1013)

96. The G.984 standard is the gigabit passive optical network ("GPON") standard that is developed, approved, and published by the ITU-T. This standard includes a number of discrete publications, including:

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- Recommendation ITU-T G.984.1 (2008), Gigabit-capable Passive Optical Networks (GPON): General Characteristics. Ex. 1011.
- Recommendation ITU-T G.984.2 (2003), Gigabit-capable Passive Optical Networks (GPON): Physical Media Dependent (PMD) layer specification. Ex. 1012.
- Recommendation ITU-T G.984.3 (2008), Gigabit-capable Passive Optical Networks (GPON): Transmission convergence layer specification. Ex. 1013.

97. G.984.1 (2008) is an ITU-T standard approved on March 29, 2008 and published not later than March 10, 2009. Ex. 1030, ¶¶41-45.

98. G.984.2 (2003) is an ITU-T standard approved on March 16, 2003 and published not later than October 31, 2003. Ex. 1030, ¶¶ 46-50.

99. G.984.3 (2008) is an ITU-T standard approved on March 29, 2008 and published not later than April 28, 2009. Ex. 1030, ¶¶ 51-55.

100. All of ITU-T G.984.1-3 are meant to be read together to describe standards for a Gigabit-PON network. Ex. 1013,, 3 ("This Recommendation forms an integral part of the G.984-series of ITU-T Recommendations that, together, specify a single coherent set of access transmission systems.").

101. Section 5 of G.984.1 describes the Architecture of the optical access network, with reference to Figure 1, reproduced below. Ex. 1011, 10.

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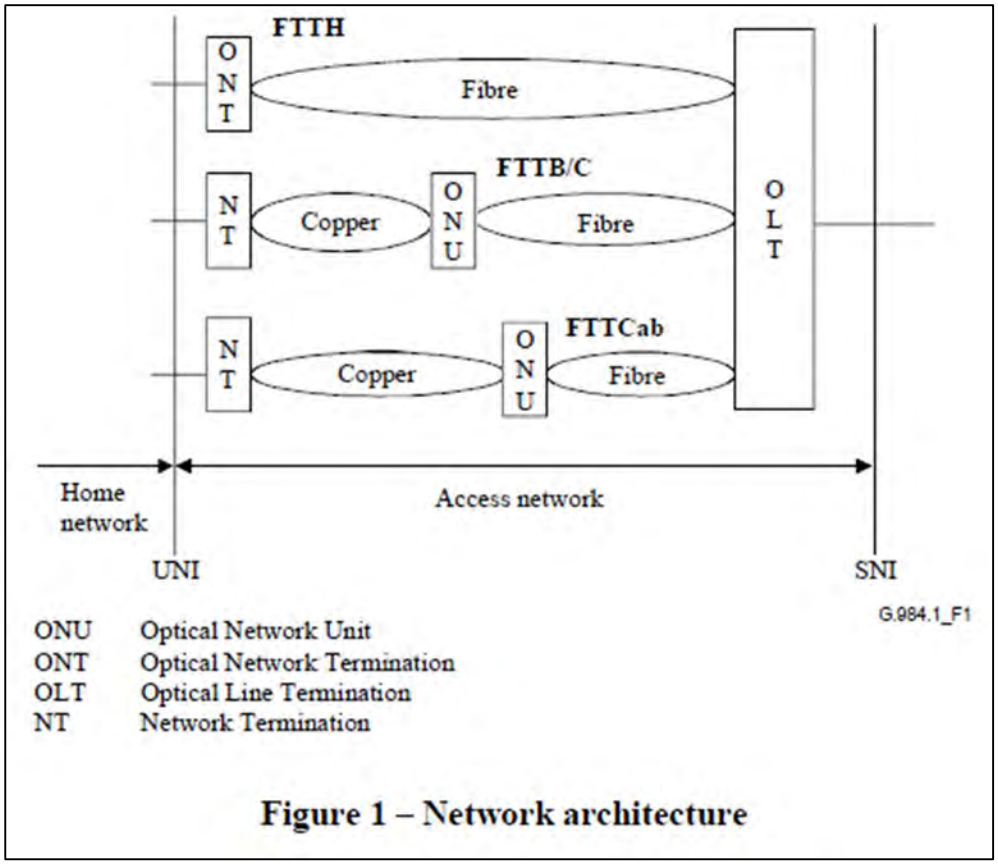
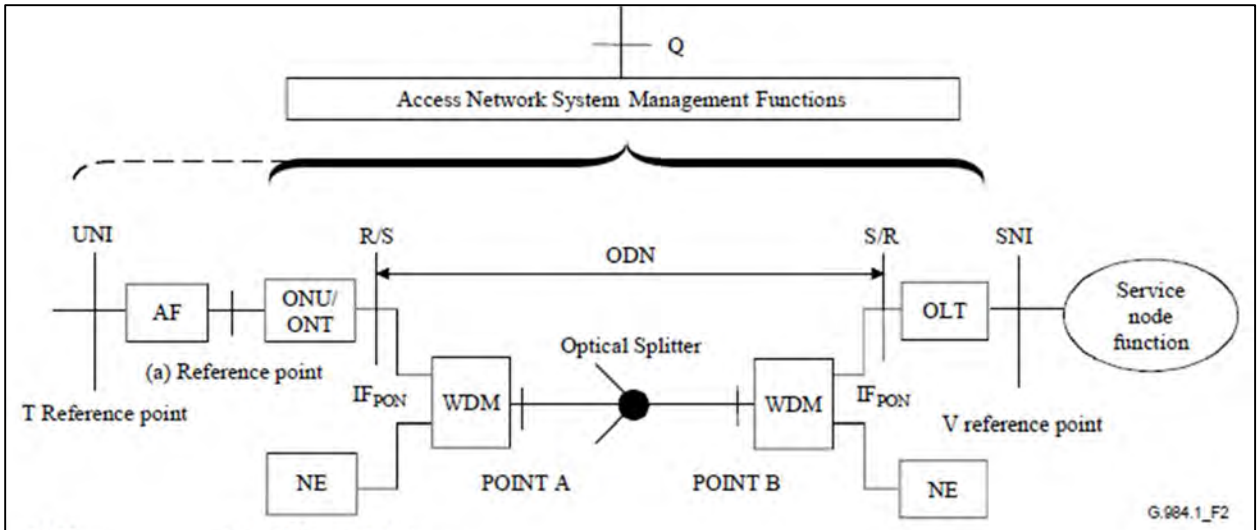


Figure 1 – Network architecture

102. G.984.1 explains that a local area network may be either active or passive (e.g., a PON), and it can be point-to-point or point-to-multipoint. Ex. 1011, 10. As shown, an ONU (or ONT) is connected via fiber to an OLT, which serves as a Service Node Interface (SNI) that connects to a switched network. *Id*., 10, 20. Figure 2 shows additional detail of the local area network, where an optical splitter is used so a signal can be provided to multiple ONUs/ONTs. *Id*., 12, Ex. 1013, 21.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

103. This network configuration "support[s] all currently known services and new services being discussed for residential subscribers and business customers, because of such a broadband capability." Ex. 1011, 12.

104. G.984.3 describes the transmission convergence layer for gigabit-capable passive optical networks – a family of flexible access networks capable of providing a range of broadband and narrow-band services, operating at the rates of

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2.48832 Gbit/s downstream, and 1.24416 or 2.48832 Gbit/s upstream." Ex. 1013, 3. The Recommendation describes "characteristics of a passive optical network (PON) with the capability of transporting various services between the user-network interface and the service node interface." *Id.*, 7. G.984.3 describes the G-PON encapsulation method (GEM) as a data transport scheme over a PON. *Id.*, 13-14. The GEM frames use a Port-ID as a key to identify GEM frames that are to be transmitted to different downstream locations (e.g., different ONUs). *Id.*, 17. The GEM frames are multiplexed using a time-division multiplexing scheme, and can be sent to multiple downstream ONUs in an aggregated data feed, as shown in Figure 5-1, below. *Id.*

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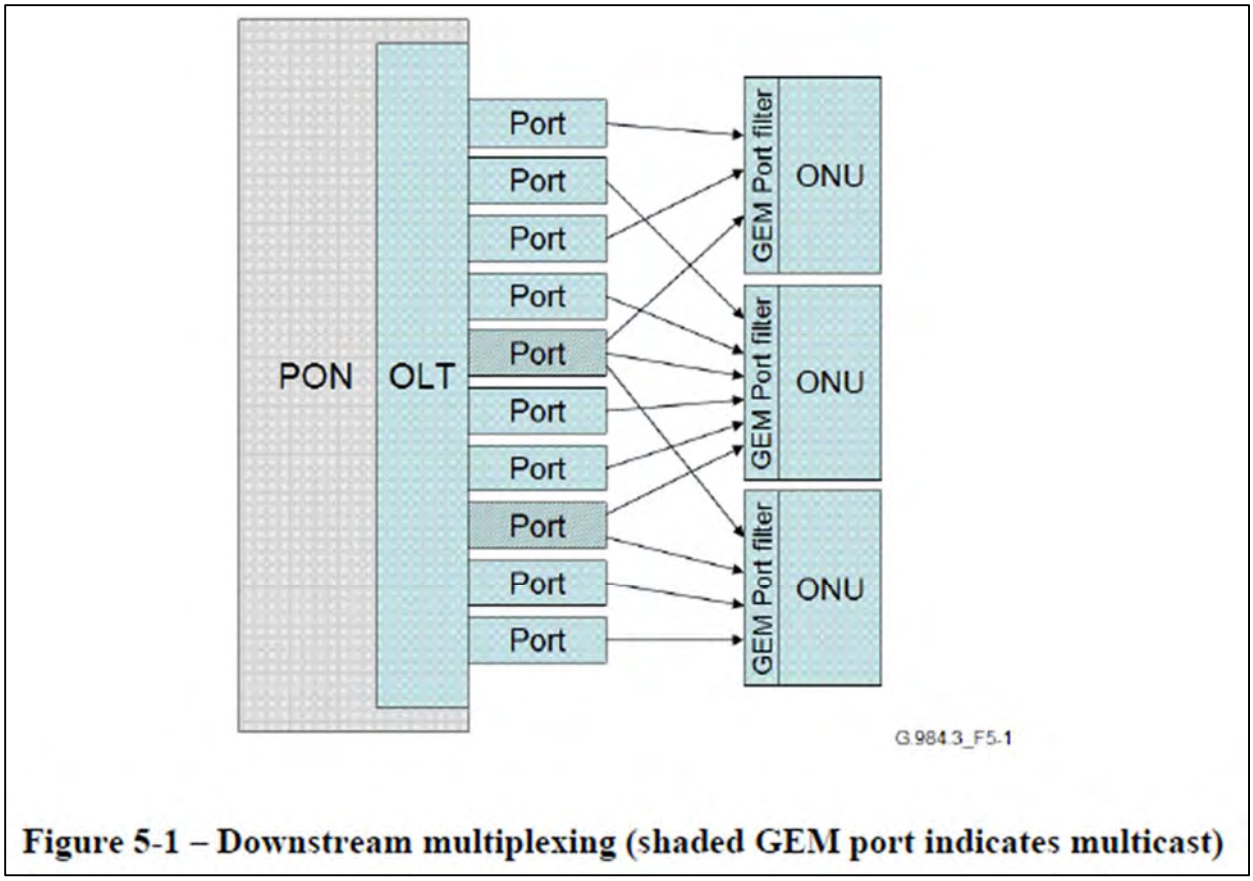

Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

Ex. 1013, 17.

105. Each ONU uses a GEM port filter that identifies relevant data frames in the multiplexed data feed, to discard those data frames that are not intended for the ONU. *Id*.

C. RFC 4364 (Ex. 1014)

106. RFC 4364, is titled "BGP/MPLS IP Virtual Private Networks (VPNs)" and was written by Yakov Rekhter and Eric C. Rosen. RFC 4364 was published in February 2006. Ex. 1030, ¶¶ 56-61.

107. RFC 4364 describes

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> This document describes a method by which a Service Provider may use an IP backbone to provide IP Virtual Private Networks (VPNs) for its customers. This method uses a "peer model", in which the customers' edge routers (CE routers) send their routes to the Service Provider's edge routers (PE routers); there is no "overlay" visible to the customer's routing algorithm, and CE routers at different sites do not peer with each other. Data packets are tunneled through the backbone, so that the core routers do not need to know the VPN routes.

Ex. 1014, *Abstract*.

108. RFC 4364 explains that "Border Gateway Protocol (BGP) [BGP, BGP-MP] is then used by the Service Provider to exchange the routes of a particular VPN among the PE routers that are attached to that VPN. This is done in a way that ensures that routes from different VPNs remain distinct and separate, even if two VPNs have an overlapping address space." *Id*., 3. When the BGP distributes a VPN route, each route is assigned a Multiprotocol Label Switching (MPLS) label (also known as an MPLS-ARCH, MPLS-BGP, or MPLS-ENCAPS label), and that label is used to encapsulate data distributed along the VPN route to allow tunneling across the backbone (the common network, or internet) to the proper PE router. *Id*., 3-4.

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109. RFC 4364 mentions several limitations of the disclosure. For example, RFC 4364 says the discussion is restricted "to the case in which the backbone provides an IP service to the customer, rather than, e.g., a layer service such as Frame Relay, Asynchronous Transfer Mode (ATM), ethernet, High Level Data Link Control (HDLC), or Point-to-Point Protocol (PPP)." *Id*., 5.

110. As discussed therein "[e]ach VPN site must contain one or more Customer Edge (CE) devices. Each CE device is attached, via some sort of attachment circuit, to one or more Provider Edge (PE) routers." *Id*. The mentioned "attachment circuit" refers to the connections between routers, such as "PPP connections, ATM Virtual Circuits (VCs), Frame Relay VCs, ethernet interfaces, Virtual Local Area Networks (VLANs) on ethernet interfaces, GRE tunnels, Layer 2 Tunneling Protocol (L2TP) tunnels, IPsec tunnels, etc." *Id*.

111. Each PE can connect to one or more CEs. *Id*., 8. Each PE "maintains a number of separate forwarding tables. One of the forwarding tables is the 'default forwarding table'. The others are 'VPN Routing and Forwarding tables', or 'VRFs'." *Id*., 9. Each attachment circuit between PE/CEs is associated, "by configuration," with one or more VRFs. *Id*. As a simple example, "when an IP packet is received over a particular attachment circuit, its destination IP address is looked up in the associated VRF. The result of that lookup determines how to route the packet. The VRF used by a packet's ingress PE for routing a particular packet is known as the

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packet's 'ingress VRF'." *Id*. The PE router encapsulates the IP packet when received from a CE device, based on the attachment circuit used to provide the IP packet to the PE router. *Id*., 10.

112. To distribute information over a VPN that touches the backbone (i.e., the main network or internet), PE routers use BGP to route data among one another. *Id*., 12. Each VPN has its own address space, so the VPN must be known before the final address can be determined. *Id*. Multiple address spaces are enabled using VPN-IPv4 address families that use a "Route Distinguisher (RD)" to identify the VPN, and a IPv4 address to identify a given IP address within the VPN. *Id*. These VPN-IPv4 addresses are each "labeled" using a MPLS address. *Id*., 17. When a PE "processes a received packet that has this label at the top of the stack, the PE will pop the stack, and process the packet appropriately." *Id*. In other words, the PE will remove the MPLS label and pass the IP packet along to the appropriate IP address using the header within the labeled packet.

113. RFC 4364 explains how IP packets are forwarded through the IP backbone among routers in a shared VPN in Section 5. *See id*., 23. "When a PE receives an IP packet from a CE device, it chooses a particular VRF in which to look up the packet's destination address. This choice is based on the packet's ingress attachment circuit." *Id*. If the packet's "next hop" (or destination PE) requires travel through the backbone, the packet is assigned an MPLS label for the route, and the

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"IP packet is turned into an MPLS packet with the VPN route label as the sole label on the label stack" and the packet is tunneled to the next PE. *Id*., 24. The recipient PE device can then determine the attachment circuit for sending the packet to the CE device, and the MPLS label is removed from the IP packet before it is sent along to the CE. *Id*., 25.

D. Ravindran U.S. Pat. Pub. 2012/0159176 (Ex. 1016)

114. U.S. Patent Publ. No. 2012/0159176 (Ravindran) is a U.S. patent application that published on June 21, 2012. Ravindran was filed by Futurewei Technologies, Inc. Ravindran is entitled "Method and Apparatus to Create and Manage Virtual Private Groups in a Content Oriented Network." Ravindran describes a content router for managing content for virtual private groups using a content oriented network (CON), which Ravindran explains could include an optical network, a DSL network, or other network type. Ex. 1016, *Abstract*. The CON provides different security levels for different users. *Id*.

115. Ravindran explains that content is shared to customer nodes/sites that can publish and/or request content over the CON. *Id*., [0030]. This is shown in Figure 1, shown below. These customer devices are arranged into Virtual Private Groups (VPGs), which Ravindran explains is "a more general term instead of VPN, as traditionally VPN has been used to indicate an Enterprise instance over a shared

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infrastructure." *Id*., [0028]. This configuration supports privacy and confidentiality of data shared over the CON. *Id*., [0029].

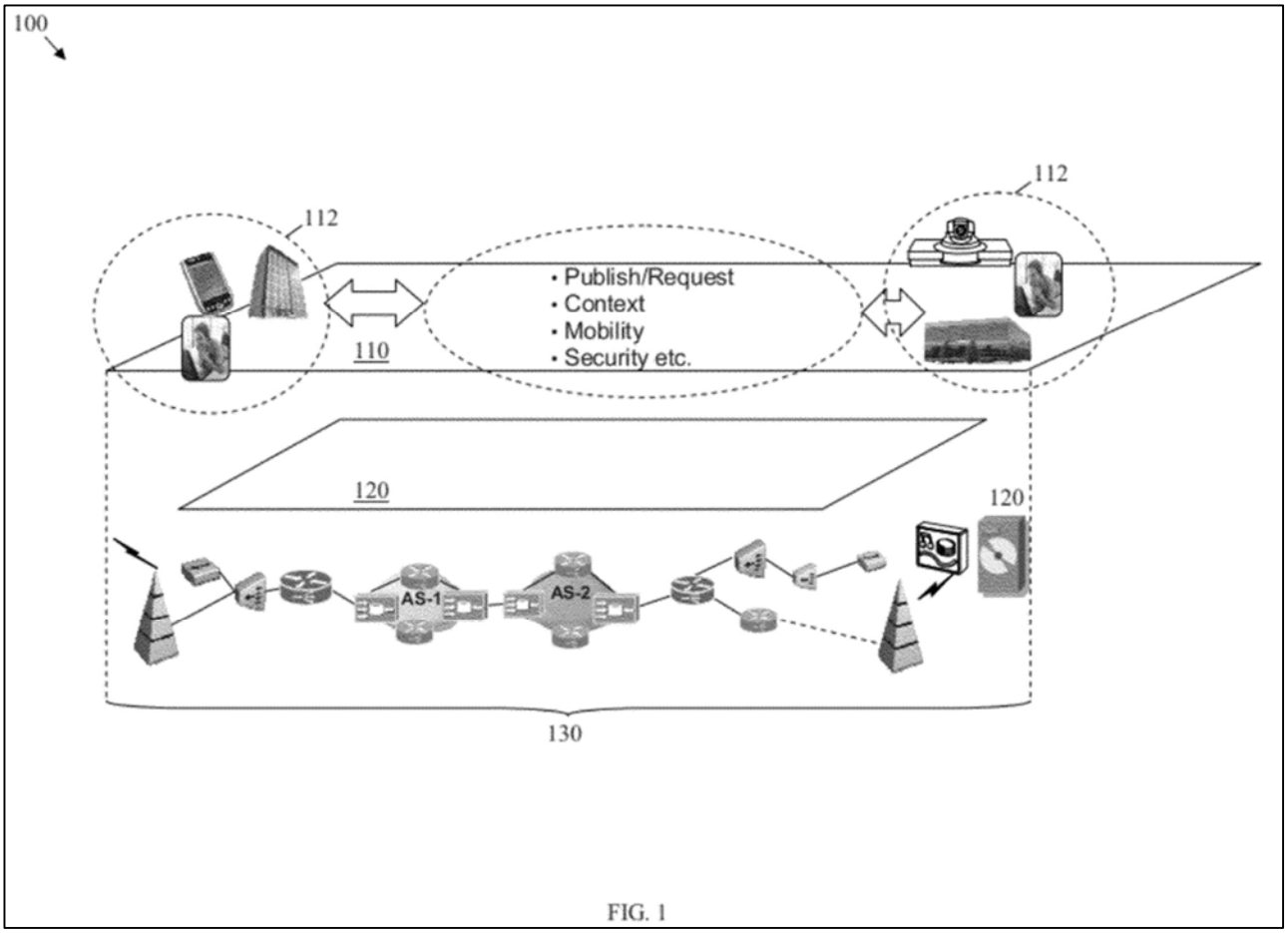

FIG. 1

116. Ravindran explains that the described concepts are usable over any network type, such an optical network in which the customer nodes/sites "may comprise optical network terminals (ONUs)." *Id*., [0031]. The network nodes are described as being "routers, switches, or bridges, such as backbone core bridges (BCBs), provider core bridges (PCBs), or label switch routers (LSRs)." *Id*., [0032].

117. Ravindran's Figure 13, shown below (and corresponding discussion), describes the use of VPN Routing and Forwarding Tables (VRFs). *Id*., [0069]-

[0070]. Ravindran explains "FIG. 13 illustrates an embodiment of a VPG transport plant virtualization 1300 that provides a plurality of forwarding instances for a plurality of VPG instances at the transport plane in a CON 1210." *Id*., [0069]. The CON comprises a plurality of content routers 1312, but only one is shown in FIG. 13. *Id*.

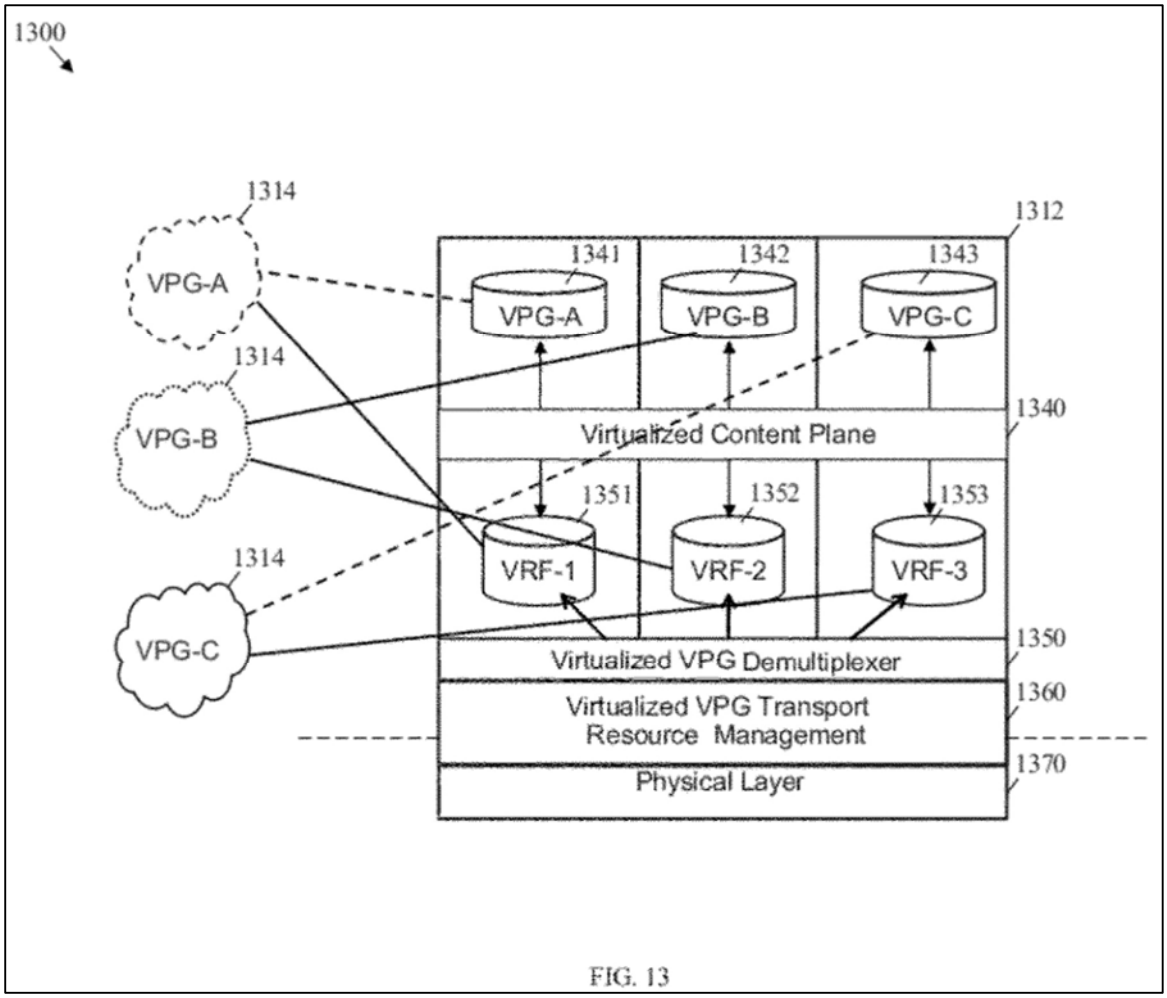

FIG. 13

118. As shown, the content router 1312 "may be configured to map existing transport virtualization constructs, such as VPN Routing and Forwarding Table (VRF), virtual router (VR), and/or Virtual Private Local Area Network Service

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(VPLS) constructs, which may be used in current networks or technologies." *Id*., [0070]. The VRFs are used to map the traffic to the correct VRF instance before the content is passed to an end user (after demultiplexing, as shown at 1350). *Id*.

E. BCM56685 Product Brief (BCM56685; Ex. 1020)

119. The BCM56685 Product Brief is a printed publication that describes the features and benefits of Broadcom's BCM56685 integrated multilayer Ethernet switch chip and provides an overview of intended implementations. The product brief is dated November 13, 2009. Ex. 1020, *generally*. The Product Brief was published on Broadcom's website at least by January 8, 2010. (https://web.archive.org/web/20100108121614/http://www.broadcom.com/products/Switching/Carrier-and-Service-Provider/BCM56685). Ex. 1020. Alternatively, the Product Brief was published on Broadcom's website no later than May 23, 2011. (https://web.archive.org/web/20110501000000*/http://www.broadcom.com/collateral/pb/56685-PB00-R.pdf). *Id*. In August 2012 (the priority date of the '142 patent), Broadcom was a leading supplier of network hardware, including switching and routing chips usable in PONs. A POSITA would have reviewed Broadcom's product portfolio and product data sheets to identify commercially available solutions for optical switches when building a PON, and therefore would have reviewed the BCM56685 product data sheet.

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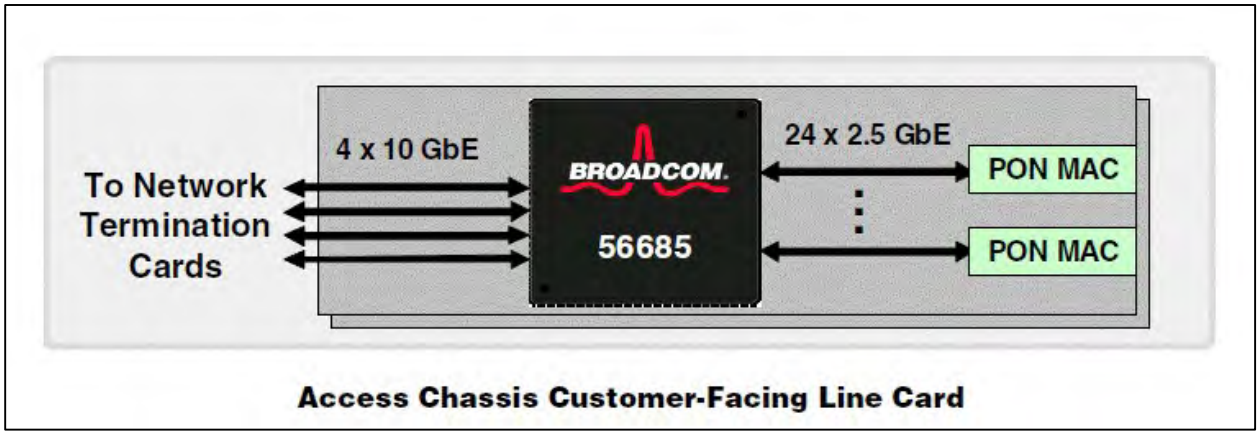
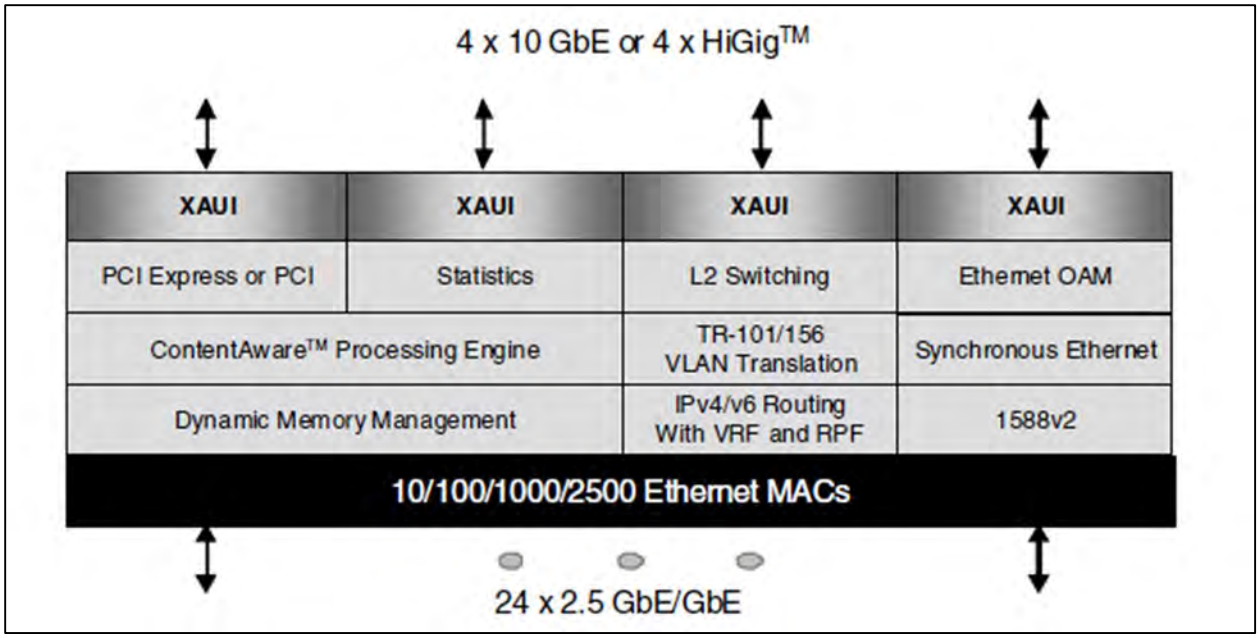
120. BCM56685 describes an Ethernet switch chip, described as a "108 Gbps Integrated Multilayer Ethernet Switch" chipset. The product brief explains that one benefit of the described switch chip is it is a "[h]ighly integrated, purpose-built solution for next-generation DSL ***and PON access equipment***" (*emphasis added*). The chip supports the latest "Carrier Ethernet transport protocols: MPLS/VPLS and 802.1ah (PBB)." *Id*.

121. The figure below is described as an "access chassis customer-facing line card" that shows the chip connects between a network termination card (e.g., an OLT) and a PON MAC.



122. Moreover, the figure below explains that the chip includes VRF features, so that the chip supports VRF-based VPNs over PONs (e.g., PONs satisfying the GPON recommendations).



XII. Ground 1: The combination of Ahn in view of G.984.1, G.984.3, and RFC 4364 renders claims 1-9 obvious.

123. The ITU-T G.984 documents (specifically G.984.1 and G.984.3) disclose all of the PON-based elements of the claims, and the RFC 4364 document discloses all of the VRF-related limitations of the claims. While I understand the Patent Owner alleges that combining these known concepts was a unique and nonobvious combination, other references, including Ahn, teach this same combination, thereby demonstrating that combining an optical network system with a VPN system using VRFs was a straightforward and known combination.

124. As I discuss below, a POSITA would have known how to combine PONs with VPNs using VRFs, and would have been motivated to do so to provide scalable VPN services on PONs. Therefore, all of the claims of the ’142 patent are obvious in light of the combination of Ahn, G.984.1, G.984.3, and RFC 4364.

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A. Alleged Novelty

125. I have reviewed Patent Owner's District Court complaint and Response to Motion to Dismiss. I understand that SPADA has stated that:

> **SPADA's methods combine the use of two things that were known in the industry at the time of the invention**. First, **a PON** for distributing signals to multiple end users. Second, **a more efficient, fast and reliable method of virtual separation of signals** than what previously existed.

Ex. 1028, 1 (emphasis added).

126. I also understand that SPADA contends that it was not known to "convey virtually separated signals through a PON." *Id*. Moreover, SPADA admits that it does not claim a new or novel method of performing VRF. *Id*., 2. For example, SPADA admits that its claims are agnostic as to how VRF is performed.

> **All that is required by the claims** is that a **PON receive and successfully deliver** to its end users **one or more data streams that have been virtually separated using Virtual Routing and Forwarding (VRF)**. **The means** used to generate such virtually separated data streams via VRF **are not claimed**.

Id. (emphasis added).

> AT&T's arguments concerning SPADA's pleading about the generation of data streams having the claimed properties (Motion 16-17) fail because **the claims of SPADA's infringed patents require**

> **only that such data steams be received, not how they are generated**.
>
> . . .
>
> AT&T's argument that the AC does not identify "the source of the 'data streams'" (Motion 16- 17) fails for the simple reason that **generation of the data streams is not claimed. All that matters is that such data streams are received.** They are. **It does not matter how those data streams are generated or what equipment is used to generate them.**

Id., 11-12 (emphasis added).

127. I also understand that SPADA admits that RFC 4364 discloses every aspect of VRF that is claimed.

> Again, **the claimed method recites data streams having certain functionality that are received – not how those data streams are generated**. Thus, it does not matter whether the AC identifies "any devices or equipment in AT&T's network that allegedly perform any functionality in the cited RFCs" (Motion 17-18). **The RFCs merely demonstrate that the data streams received by AT&T's PONs have the claimed properties**.

Id. at 12 (emphasis added).

> VRF is used to generate virtually separate private data streams in accordance with the RFC 4364 Standard and the supporting RFC 4381 Standard and RFC 4382 Standard.

Ex. 1027, ¶ 14.

128. I understand that SPADA contends that the use of GPON networks that receive traffic separated by VRF infringes the claims of the '142 patent.

> The AC identifies AT&T's PON-based high-speed fiber services as the accused instrumentalities (¶ 10). These include GPON (Gigabit PON) and XGS-PON (10 Gigabit Symmetrical PON) technologies[.]

Ex. 1028, 5.

> The AC (at ¶¶ 17 and 28) explains how AT&T's network receives virtually separated data streams form by VRF in compliance with RFC 4364. The AC details how AT&T's use of such data streams supports the secure and scalable transmission of data and connects this functionality to AT&T's XGS-PON and GPON deployments.

Id., 8.

> There are **standards for creating virtually separated data streams**, and there are different **standards that govern how PONs operate**. **Both sets of standards apply here to different aspects of SPADA's claimed method**.

Id., 11.

B. Motivation to Combine

129. A POSITA would have been motivated to combine Ahn, G.984.1, G.984.3, and RFC 4364, to use VRF-based virtual data separation (as discussed in Ahn and RFC 4364) on a PON as described in Ahn, G.984.1, G.984.3, which is a fiber optic network that uses passive splitters to distribute optical signals to multiple

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end users. Ahn describes this concept generally, and a POSITA would have been motivated to look at relevant recommendation documents, including G.984.1 and G.984.3 for details relevant to implementing the most prevalent PON, and RFC 4364 for details for implementing VRF.

130. Ahn explains that "PONs (Passive Optical Networks) have emerged as an alternative for subscriber network technology, offering a low-cost, simple and scalable architecture that supports data, voice, and video services." Ex. 1015, 1. Since PONs have become prevalent infrastructures for providing data to end users, and because some end users have used VRFs as an alternative to "global" routing tables for end users, a POSITA would have been motivated to take advantage of PONs' benefits when implementing VRF technologies that, at the time of Ahn's publication, were "currently being standardized by the IETF's PPVPN, PWE3 (Pseudo Wire Emulation Edge to Edge) working groups." *Id*. Specifically, at the time of the '142 patent priority date, a POSITA would have been motivated to look at published documents from the organization developing VPN standards. As Ahn recognizes, a POSITA would have looked at "RFCs already published by the IETF." *See id*., 4. At the time of the '142 patent priority date, those documents included RFC 4364, which superseded RFC documents referenced by Ahn. *See id*., 4. According to Ahn, "[w]hen these technologies are applied to Ethernet-PON-based optical subscriber networks, subscribers seeking to establish VPNs can do so with

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minimal equipment and at a lower cost compared to conventional subscriber-based VPNs." *Id*.

131. A POSITA would have had a reasonable expectation of success, because data that was virtually separated using VRF could be transported to end users across a PON. A PON is an access network that connects subscribers to a service provider. The physical structure of a PON is agnostic as to the type of data sent over it (and regardless of whether the data is virtually separated). The service provider of a PON maintains an optical line terminal ("OLT") in the central office, which is connected to a number of optical network units ("ONUs") that convert optical signals to electrical signals that are sent to end users. The OLT and ONUs are connected by the ODN, which is the fiber optics and splitters that carry the optical signals between the OLT and ONUs. PONs were known at least a decade prior to the '142 patent and have been used for transmitting both private and public data to end users – indeed, Ahn discusses transmitting data that has been virtually separated using VRF over a PON. For example, the GPON recommendations were finalized and published by the ITU-T in 2003. Ex. 1030, ¶ 41. And GPON superseded the older EPON (ethernet PON) standards in existence prior to 2003. Ex. 1015, 3. APON/BPON technologies preceded EPON, and those standards (G.983.1-4) were first published in 1998. *See generally* Ex. 1025.

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132. VRF is a software-based technology that allows a single router to simultaneously maintain more than one routing table for transmitting data to different end user locations (each end user location has a different routing table at the router). VRF enables one physical device to act as multiple routers and can route data to multiple end points along a single communication line (e.g., a single optical line). In some cases, the router can implement a global routing table for end users that do not use a VRF-based VPN *and* one or more VRFs. Because the data separation is "virtual," VRF data separation does not require any specific physical structure to configure a service provider router to virtually separate data intended for different end users. For example, RFC 4364 describes a method by which a Service Provider uses an IP backbone to provide IP Virtual Private Networks (VPNs) for its customers through the use of VRF. Ex. 1014, 1.

133. Ahn describes a PON system that transports traffic that has been separated by VRF through, for example, VPNs separated with L3 MPLS labels. In other words, a PON is agnostic to whether traffic has been "virtually" routed or routed by distinct routers upstream of the OLT. As such, a POSITA would have known that traffic that had been virtually separated by VRF upstream of an OLT could be distributed to a specific end user over a PON. For example, Ahn describes "the functional requirements of Optical Network Units (ONU) and Optical Line Terminals (OLT) necessary to develop VPN technology for L2/L3 MPLS-based

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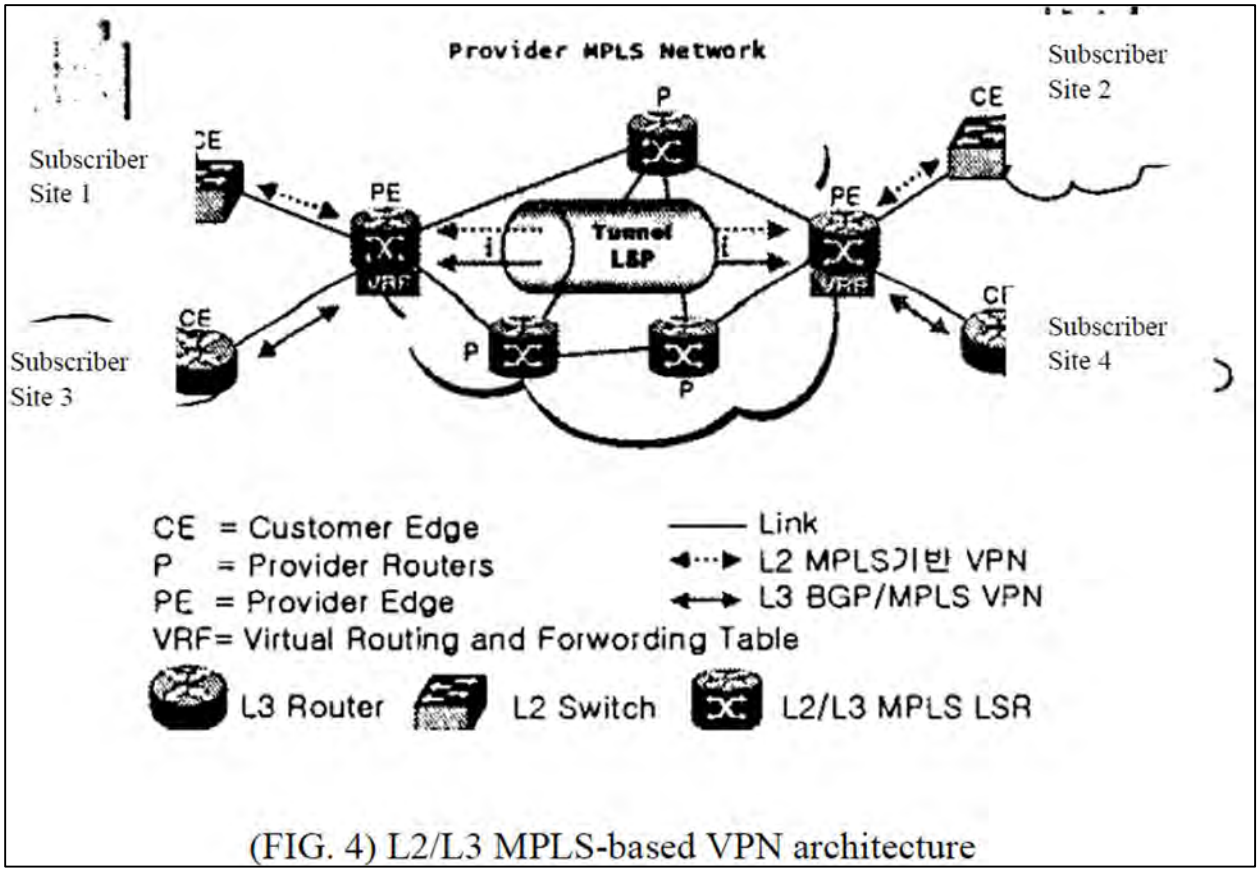
network subscribers on Ethernet-PON (E-PON)-based optical subscriber networks that are linked with an MPLS/IP backbone." Ex. 1015, 1. Ahn recognized that, as of a decade prior to the '142 patent, "PONs (Passive Optical Networks) have emerged as an alternative for subscriber network technology, offering a low-cost, simple and scalable architecture that supports data, voice, and video services." *Id.* Ahn also describes deploying "L2/L3 MPLS-based VPN technology" on a PON with the use of VRF. *Id.*, 3.



(FIG. 4) L2/L3 MPLS-based VPN architecture

134. As shown in FIG. 4, above, Ahn describes the use of VRF[4] in provider edge ("PE") devices, which can be routers.

> In a PE device, the table in which the port information associated with the subscriber site and the routing information for subscriber traffic is registered is referred to as an VRF (VPN Routing and Forwarding) table

Ex. 1015, 3.

135. Ahn also describes a VPN can encompass two or more subscriber sites that are connected with routers that utilize VRF. *Id*. at 3 ("Traffic between subscriber sites is sent to the adjacent PE, and then the PE transmits the traffic to the LSP that is registered in the VRF, thereby operating the VPN."). Ahn further teaches utilizing L3 BGP/MPLS-based VPN technologies in conjunction with a PON whereby OLTs also act as routers managing VRF tables. *Id.*, 4 ("Accordingly, to enable the exchange of routing information between dispersed subscriber sites, the OLT must implement Multi-Protocol BGP (MP-BGP) functionality, which extends the capabilities of conventional BGP. In MP-BGP, routing information for IPv6, IPX, VPN-IPv4, and the like, can be exchanged. In addition, the OLT can manage VRF tables to map subscriber traffic to the MPLS tunnels."). As explained in RFC 4364,

[4] Ahn says VRF means "VPN Routing and Forwarding;" this is another expression for "virtual routing and forwarding" which provides VPN-levels of privacy.

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"[e]ach route within a VPN is assigned a Multiprotocol Label Switching (MPLS)[] label; when BGP distributes a VPN route, it distributes an MPLS label for that route." Ex. 1014, 3. Ahn concludes by noting the "functions that need to be implemented in OLTs/ONUs to support L2/L3 MPLS-based VPN services within an Ethernet-PON architecture." *Id*. "To provide such VPN services, OLT subsystems must include functionality for mapping specific VPN subscriber traffic, differentiated by VLAN ID at L2/L3, to the MPLS tunnel." *Id*.

136. While Ahn identifies EPON as the prevailing PON standard at the time of its 2002 publication, GPON was released the following year and became the most prevalent PON standard by the time of the alleged '142 patent invention. A POSITA reading Ahn would have been motivated to look to more modern PON standards (e.g., GPON as discussed in G.984.1 and G.984.3) and the modern RFCs relevant to VRF (including RFC 4364) to provide a wide compatibility with other devices (e.g., including modern devices using the most modern PON standard). Similarly, Ahn specifically cites RFC 2547bis as relevant to "BGP/MPLS VPN method for providing VPN over an IP backbone." RFC 2547 was superseded by RFC 4364 (Ex. 1015, 3-4) so a POSITA would have been motivated to look to RFC 4364 for additional information regarding VRF and would have had a reasonable expectation of success in combining Ahn with RFC 4364, particularly when implementing the

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concepts of Ahn with the more modern GPON recommendations discussed in G.984.1 and G.984.3.

137. A POSITA would have had a reasonable expectation of success in combining Ahn, G.984.1, G.984.3, and RFC 4364, because a POSITA would have known that GPON (as discussed in G.984.1 and G.984.3) and EPON (as discussed in Ahn) are interchangeable with respect to the use of VRF tables for distributing data to end user devices, as discussed in Ahn. Both GPON and EPON deliver data to end users over optical networks by aggregating data destined for multiple ONUs into an aggregated data feed, and each ONU is configured for identifying only those data packets relevant to it, and to discard data packets destined for other ONUs.[5]

138. A POSITA would have been motivated to look to both the prevalent PON standards of the time (GPON) for additional information regarding PONs and

[5] Commercial products were available at the time of the '142 patent filing that enabled VRF over a PON, which provides real-world evidence that a POSITA would have had a reasonable expectation of success in combining these references. BCM56685 is a published Broadcom datasheet that describes the features and benefits of an Ethernet switch chip that was available prior to the time of the '142 patent filing date. The data sheet indicates that this chip supports "IPv4/v6 Routing with VRF and RPF."

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the relevant VRF documentation (RFC 4364) for additional information regarding VRF. A POSITA would have also had a reasonable expectation of success in implementing the teachings of G.984.1, G.984.3, and RFC 4364, with Ahn, at least because G.984.1, G.984.3 and RFC 4364 describe implementation details of the technologies discussed in Ahn.

C. Claim 5

1. [5.PRE] A digital network communication method comprises:

139. To the extent the preamble is limiting, a POSITA would have understood Ahn, G.984.1, and RFC 4364 teach this limitation.

140. The '142 patent discloses that components of a system are "used to provide a mutually secure, shared Local Area Network ("LAN") implementation which can supply a multi-tenant site such as an office building [] with converged voice, data and video signal traffic at gigabit speeds to a plurality of mutually secure end point users such as building tenants having multiple end user devices such as computers, access points and wireless controllers, application servers and printers, and television sets." Ex. 1001, 3:62-4.

141. Digital data network communication methods are nothing new and are the subject of many standards. G.984.1 discloses a digital data network communication method. For example, G.984.1 describes a passive optical network, which is a network that is used for digital communications. Ex. 1011, *generally*.

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G.984.3, a companion to G.984.1, also describes a network that is used for digital communications. Ex. 1013, *generally*. These networks transmit data digitally, using digital light signals transmitted across optical fibers. *See id*., 20 (describing laser "bursts" that transmits a digital pattern of zeros and ones into the optical fiber).

142. RFC 4364 and Ahn also describe digital data network communication methods. RFC 4364 describes how "[d]ata packets are tunneled through the [IP] backbone" between end points. Ex. 1014, 1. This is also reflected in Ahn, which describes networking systems over broadband fiber-optic cable (using digital light signals to convey data) to provide high-bandwidth data sharing among end points. Ex. 1015, 1.

2. [5.A] receiving from at least one passive optical network (PON) interface router out of a plurality of PON interface routers at a PON optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices;

143. A POSITA would have understood Ahn, G.984.1, and RFC 4364 teach this limitation.

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144. The ’142 patent explains that the PON interface routers “can be configured with Virtual Routing and Forwarding (VRF)” and “Virtual Local Area Network (VLAN) tagging” to “separate and manage the distribution of voice, video and data content traffic to each of the users.” Ex. 1001, 4:52-56. This allows “data traffic intended for one tenant is automatically isolated from traffic intended for other tenants.” *Id*., 5:50-52. The ’142 patent describes the functionality of an OLT for receiving a plurality of data streams including IP data packages from a PON including a private data stream that has been virtually separated using the above-mentioned VRF with respect to Figure 4. The ’142 patent explains that Figure 4 (reproduced below) “represents the Passive Optical Network infrastructure which is an optical distribution network used to convey the photonic broadcast stream feeds that contain the encrypted data packets such as VLAN-tagged ethernet frames.” Ex. 1001, 6:58-62. Those data packets are part of telecommunications service traffic that includes Internet, public switched telephone networks, and broadcast/cable television to ONUs that service at least one private user. *Id*., 4:23-26.

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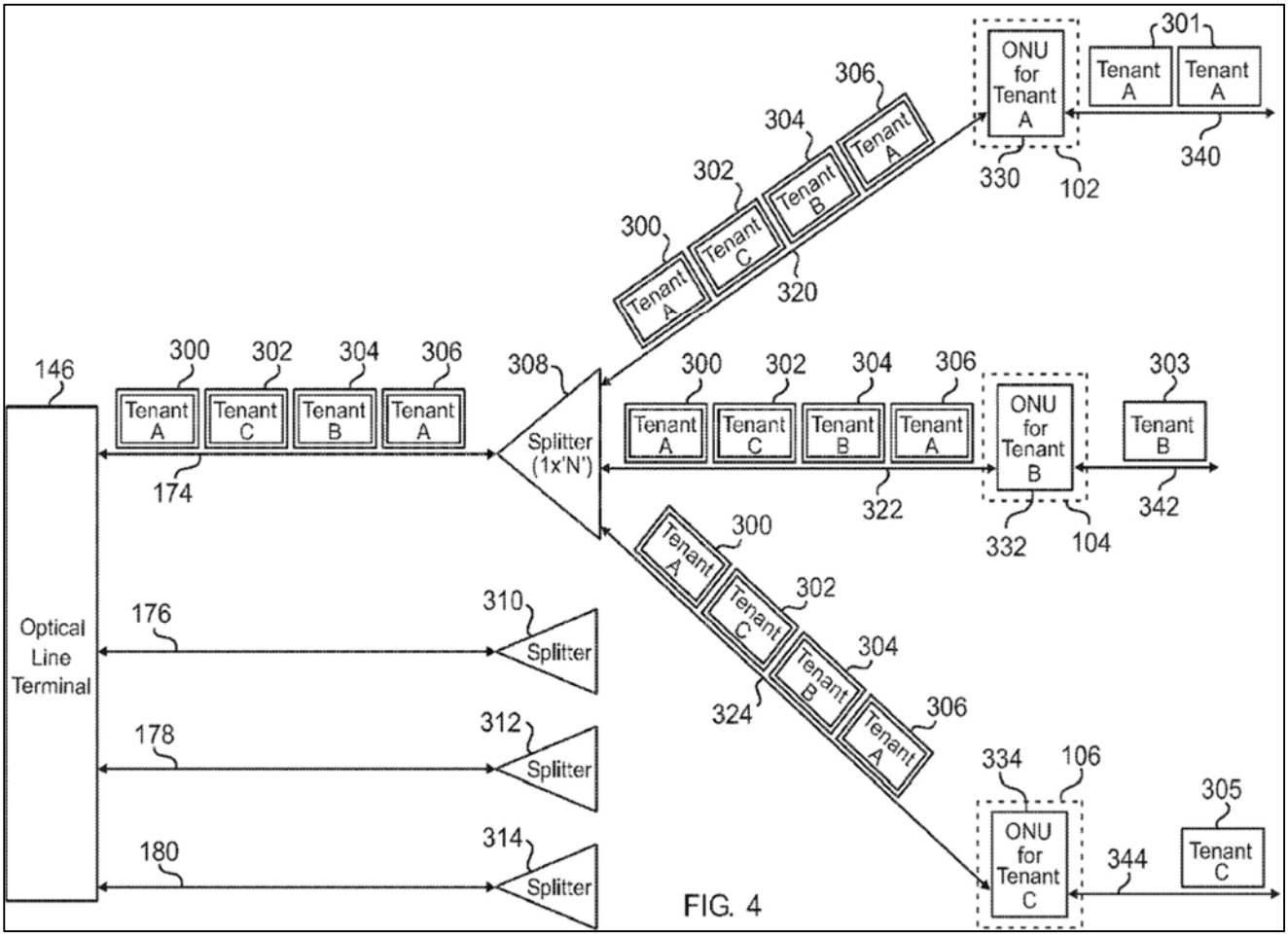
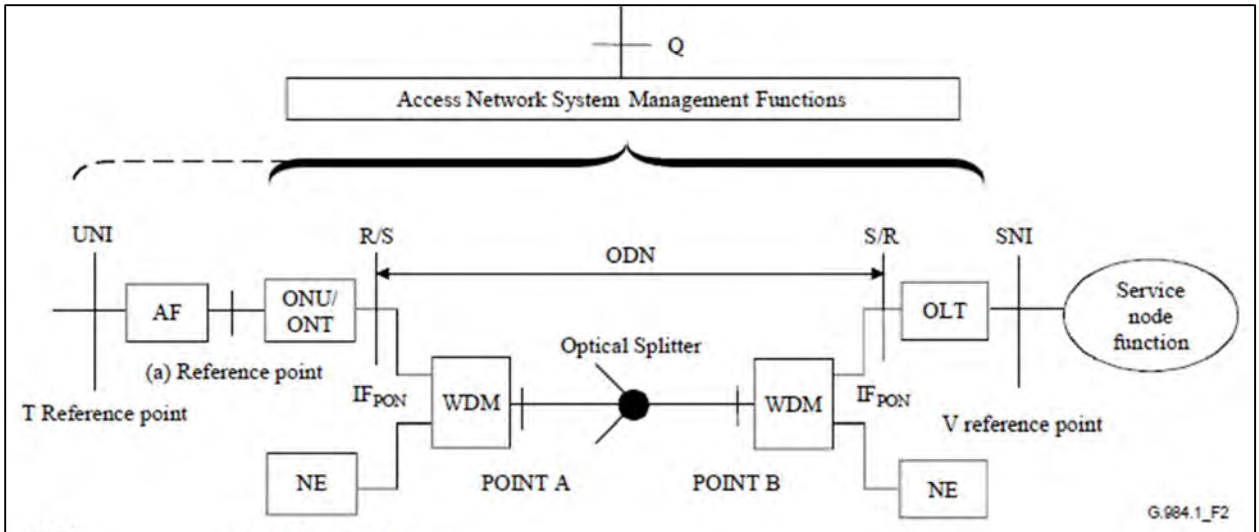


FIG. 4

145. G.984.1 discloses "receiving [data streams] from at least one passive optical network (PON) interface router out of a plurality of PON interface routers at a PON optical line terminal (OLT)." G.984.1's Figure 2, reproduced below, shows the architecture of a PON, for example, data streams are forwarded from the service node function to an OLT before the data streams are provided to the end users (at an ONU). Ex. 1011, 12.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

146. As shown, the GPON standard contemplates that OLT's are connected to an "edge routing device." Ex. 1011, 26 (describing traffic leaving the PON towards the service network, explaining that "traffic . . . leaves the OLT over some type of Ethernet interface, for connection to an edge routing device or other Ethernet aggregation device."). the illustrated OLT is connected with the "service node," which is the edge router of the PON (functionally, the "PON interface" router) so

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the OLT receives data streams transmitted from the PON, through an appropriate router. *Id.*

147. Moreover, the PON (as discussed in detail in G.984.1-3) is agnostic to the data transmitted through it. RFC 4364 discloses transmitting at least one private data stream that has been virtually separated using VRF to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages out of a plurality of data streams over a network, and Ahn explains that a private data stream as disclosed in RFC 4364 is transmitted over a PON. Ex. 1014, 1; Ex. 1015, 3. Therefore, Ahn explains that data streams "received" from at least one passive optical network (PON) interface router (that is configured according to G.984.1) are "virtually separated" using VRF and comprise IP data packages that are intended for an ONU.

148. The private data stream disclosed in RFC 4364 has been virtually separated using VRF (as discussed in Ahn) to form at least one virtually separated private data stream. As discussed above, RFC 4364 is directed to "a method by which a Service Provider uses an IP backbone to provide IP Virtual Private Networks (VPNs) for its customers." Ex. 1014, 1. RFC 4364 describes a "'peer model', in which the customers' edge routers (CE routers) send their routes to the Service Provider's edge routers (PE routers); there is no 'overlay' visible to the customer's routing algorithm, and CE routers at different sites do not peer with each

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other." *Id*. Thus, the data streams discussed in RFC 4364 are "private" using the described VPN configuration. RFC 4364 describes a first PE router forwards/tunnels an IP packet within a MPLS packet to "the next hop," such as a second PE router "where the VPN label will be examined. *Id*., 25. RFC 4364 describes implementing VRF within PE routers such as those discussed in Ahn to virtually separate traffic into one or more virtually separated private data streams. The treatment of a packet received at the second PE router depends on the VPN route label of the received packet in the at least one virtually separated private data stream of the received plurality of data streams. *Id*. The second PE "may only be able to determine that the packet's destination address needs to be looked up in a particular VRF before being forwarded to a CE device." *Id*. As explained in Section 3 of RFC 4364:

> 3. VRFs: Multiple Forwarding Tables in PEs
>
> Each PE router maintains a number of separate forwarding tables. One of the forwarding tables is the "default forwarding table". The others are "VPN Routing and Forwarding tables", or "VRFs.

Ex. 1014, 9.

149. Moreover, Section 5 of RFC 4364 provides a description of a process for virtually separating a private data stream and forwarding the same to the intended private user device. This section includes a step-by-step logic flow of how a PE

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router handles an IP packet received from a CE device for forwarding to another CE device associated with an intended recipient:

150. First, a PE router receives an IP packet from a CE router. Ex. 1014, 23. The PE router then “chooses a particular VRF in which to look up the packet’s destination address.” *Id*. This is the first step in the claimed "virtual separation."

151. Next, the PE router looks up the packet’s destination IP address of the “at least one private user device” in the located VRF. Assuming a match is found, the PE learns the packet’s “next hop” (i.e., the CE router destined to receive the IP packet. *Id*., 23-24. Because the packet is sent over a VPN, the PE router does not perform a lookup in the main routing table or any other customer's VRF. The routing table used to lookup the CE router and IP address is the claimed "independently unique virtual routing table." *Id*.

152. Based on the result of that VRF lookup, the PE router determines the next hop and, when the next hop requires passing the packet across the main backbone, the PE router encapsulates the packet (e.g., using an MPLS label) for transport across the provider's network to the packet’s destination address. The encapsulation discussed in RFC 4364 creates at least one virtually separated private data stream comprising one or more Internet Protocol (IP) data packages that is a "virtually separated private data stream" isolated from all other traffic and intended for an ONU that serves at least one private user device of a plurality of ONUs. *Id*.,

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24. The plurality of ONUs serve a plurality of user devices. Accordingly, RFC 4364 explains that a PE router (e.g., of a PON) can virtually separate at least one private data stream comprising IP data packages intended for at least one ONU serving at least one private user device of a plurality of ONUs from a plurality of data streams as recited in [5.A], and the virtually separated data streams, including the at least one private data stream can be subsequently received at an OLT.

153. Ahn's description of a network structure incorporating VRF over a PON is the same as what is described in RFC 4364 and G.984.1, demonstrating that Ahn intends to use the VRF and PON concepts discussed in prevailing recommendations, such as those in RFC 4364 and G.984.1. Ahn states that "[c]ommunication networks consist of a backbone network, a subscriber network, and a user network." Ex. 1015, 1. Ahn further teaches that the "subscriber networks are responsible for multiplexing data from the user network, transmitting it to the backbone network, and distributing the downstream traffic of the backbone network." *Id.* Ahn teaches that these subscriber networks are often PONs. *Id*. ("To address these challenges, technological development of Ethernet PON systems that can significantly reduce the cost of laying fiber optic cable while delivering high-speed communication to end subscribers, and standardization are both in progress."). As evidenced by Ahn, a POSITA would have known that data traffic leaving a PE router (as disclosed in RFC 4364) to be distributed to end users over a PON access

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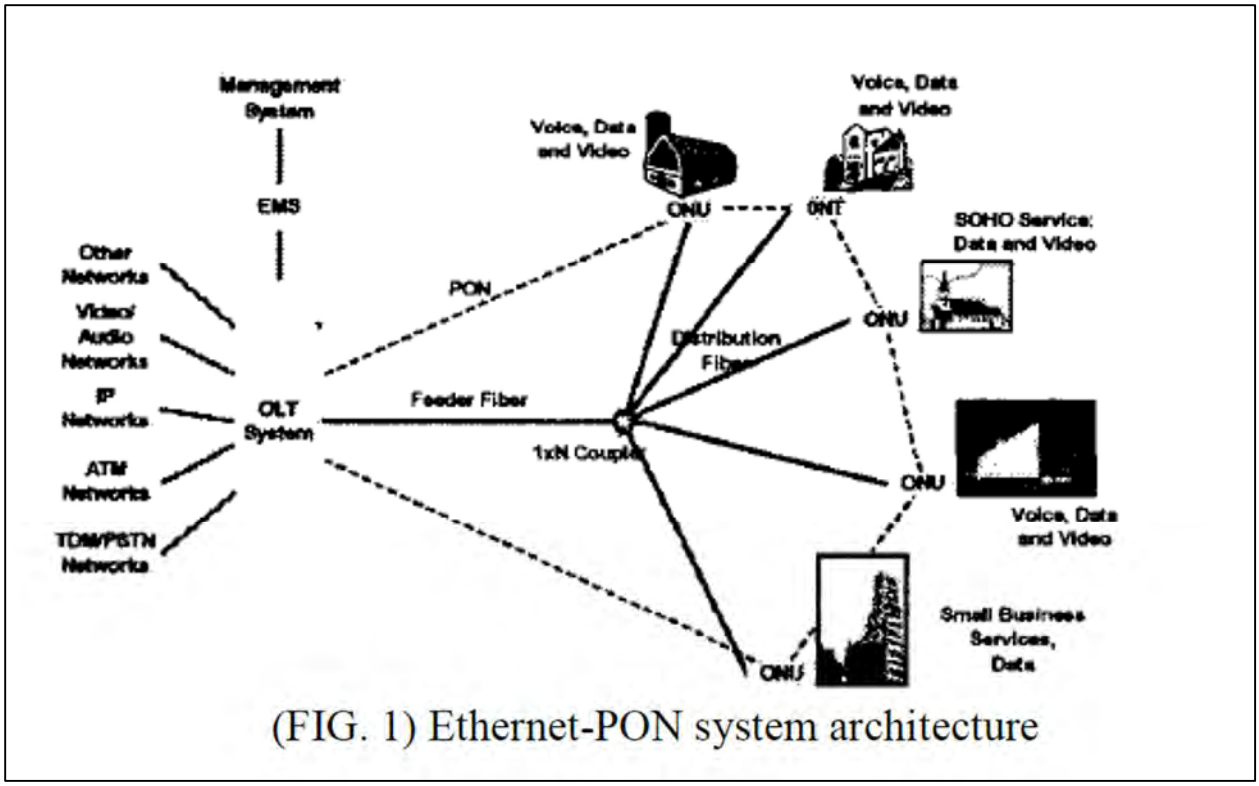
network would be passed from an OLT to ONUs. Ahn also teaches that these PON networks consist of an OLT that connects to the IP backbone of a network with links to a router that interfaces with the PON (a "PON interface router" as recited in the claims)

> Ethernet-PON systems broadly comprise OLT subsystems, ONU or ONT (Optical Network Terminal) subsystems, and ODN (Optical Distribution Network). Viewing (FIG. 1), the architecture of a PON comprises one OLT system and N ONUs via the ODN. The OLT system has a plurality of PON links to end subscribers, and is connected to ATM, PSTN, IP backbones, or the like.

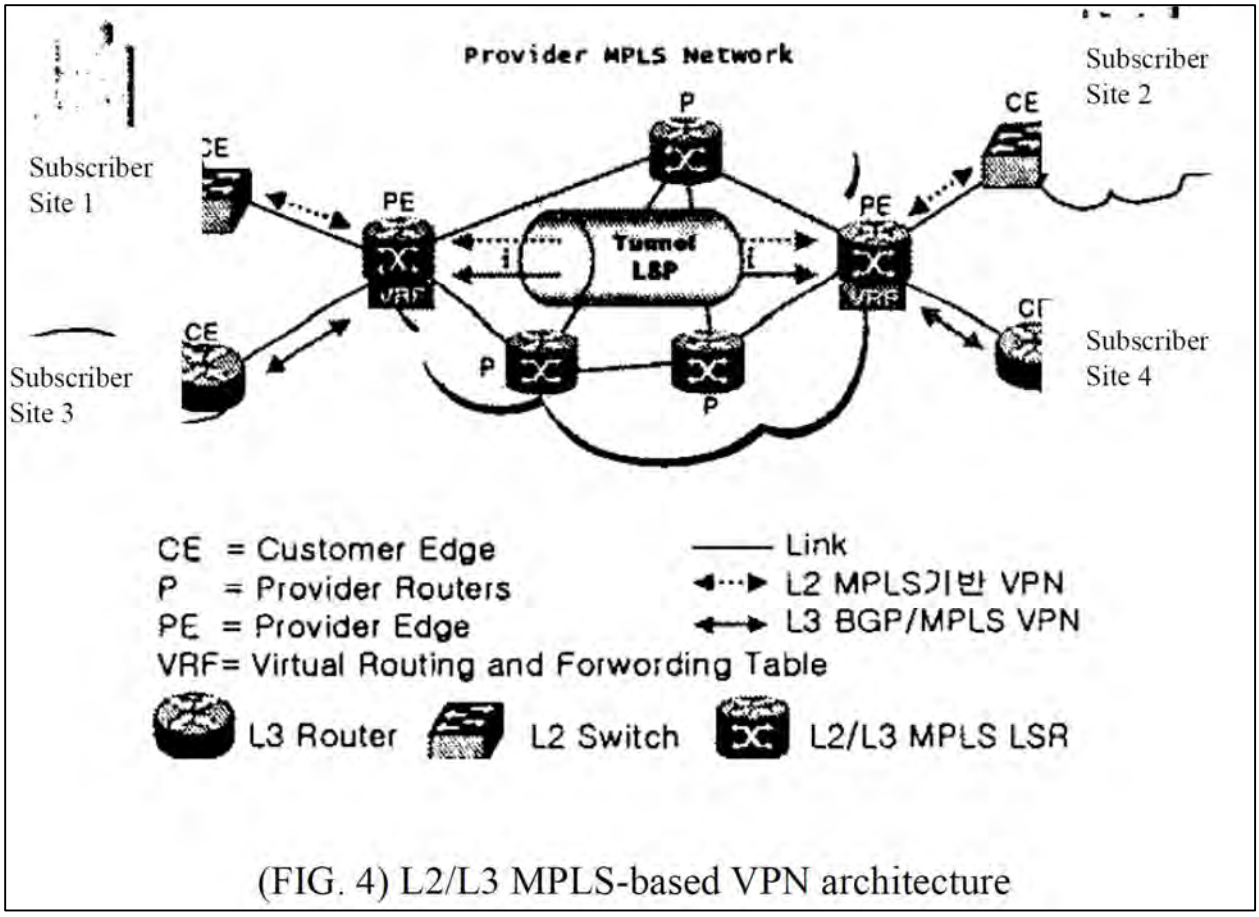
Id.

154. The OLT is also connected to a plurality ONUs at customer locations, as shown in FIG. 1, reproduced below. *Id*.



(FIG. 1) Ethernet-PON system architecture

155. Ahn also discloses the use of PE routers and CE routers at the provider and customer edges respectively, as described in Section 3 and depicted in Fig. 4.



(FIG. 4) L2/L3 MPLS-based VPN architecture

156. The PE and CE devices are connected by means of a PON access network. Ex. 1015, 3. Because the OLT is connected to the IP backbone and the plurality of customer locations (the ONUs), the OLT is connected to a provider edge (PE) of the IP backbone network as discussed in Ahn and in RFC 4364, so that the PE (e.g., the secondary PE of RFC 4364) forwards the plurality of data streams that are destined for ONUs connected with the OLT, including the at least one virtually separated private data stream containing said IP data packages. Ex. 1015, 2.

157. As discussed above, a POSITA would have been motivated to combine the VRF teachings of RFC 4364 with the standardized PON architecture of G.984,

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including G.984.1 and G.984.3, in the configuration described by Ahn, so that a VPN using VRFs is implemented on a PON. The GPON recommendations are agnostic to the type of traffic that are received and, according to G.984.1, "GPON is required to support all currently known services and new services being discussed for residential subscribers and business customers, because of such a broadband capability." Ex. 1011, 12. As described above, Ahn explicitly teaches using VRF across a PON and a PON OLT receiving VRF separated private data streams at an OLT from a router that supports the PON. Further, a POSITA would understand that VRF could be used in a router device upstream of the PON OLT. Furthermore, a POSITA would have understood that VRFs would have been equally applicable to GPON-based networks as the EPON-based networks discussed in Ahn. Ahn was published nearly a decade prior to the priority date of the '142 patent, and focused on EPON networks that were most prevalent at the time of publication of Ahn. The GPON recommendations were introduced in 2012 as the preferred and prevalent embodiment of a PON at the time of the '142 patent. A POSITA would have been motivated to look to the GPON (G.984.1-3) standard to implement VRFs using the most prevalent PON standard, and a POSITA would have understood that differences between EPON and GPON standards would not have hindered implementation of VRFs in the manner described by Ahn.

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3. [5.B] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;

158. As shown in Figure 4 of the ’142 patent (shown above), data streams for multiple tenants (specifically, Tenant A, Tenant B, and Tenant C) are all included in a common data feed. Ex. 1001, 6:58-67. As the ’142 patent explains “the OLT can broadcast the combined encrypted VLAN-tagged ethernet frames 300, 302, 304, 306 over the distribution feeds 174, 176, 178, 180 to a number of splitters 308, 310, 312, 314.” *Id*.

159. G.984.1 and G.984.3 disclose this functionality of PONs. As shown in Figure 2 of G.984.1, shown below, signals are distributed to multiple end users using an optical splitter – a device that does not have any inherent ability to distinguish between different signals to different end users based on their intended end users. Instead, signals for any end user are included in the same, aggregated signal, and the signal is split using the optical splitter so that all end users receive all data signals in a single data feed. *See* Ex. 1011, 12.

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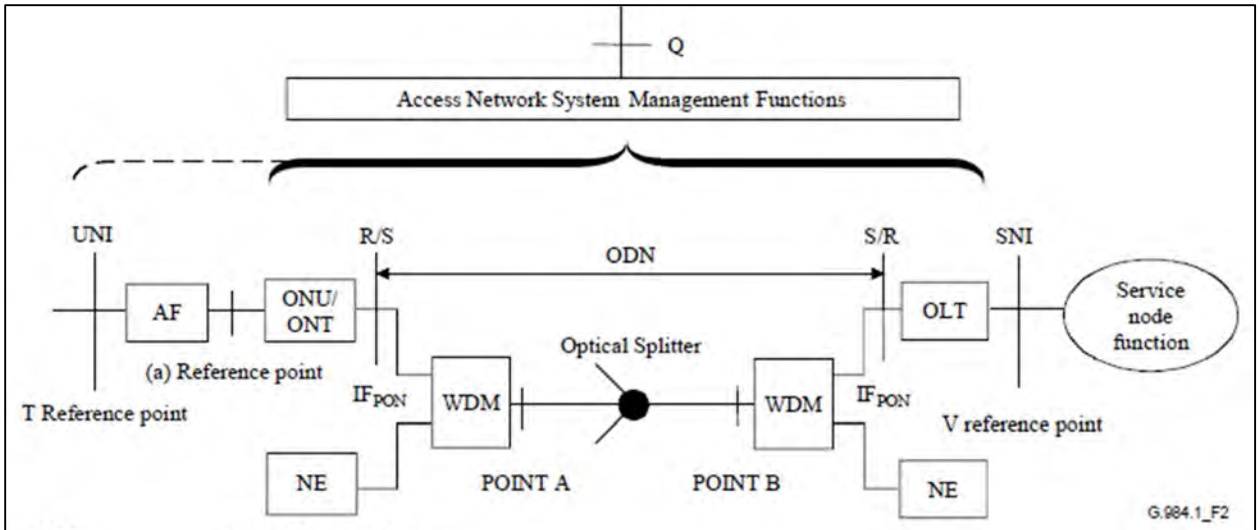

ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

160. G.984.3 provides more detail about how data for different ONUs can be aggregated onto a common data feed, using time division multiplexing and GEM Frame-IDs that each receiving ONU uses to determine which data frames are relevant for the receiving ONU. Ex. 1013, 17.

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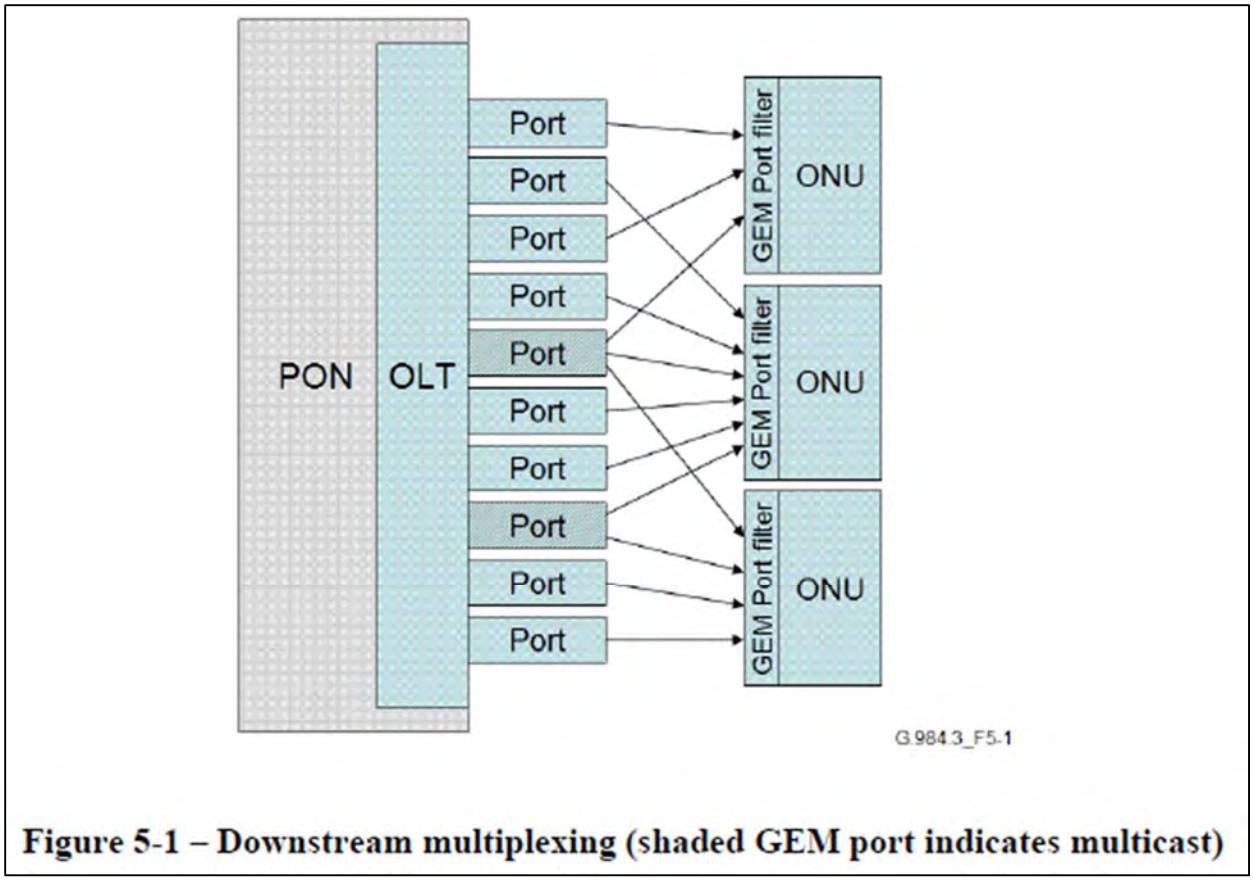

Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

161. Ahn also discloses "aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed."[6] Ex. 1015, 2. Ahn explains that the OLT of a PON transmits a single data feed to the plurality of connected ONUs that is split by an optical splitter.

[6] While there are some differences between how GPON (as discussed in G.984.1-3) and EPON (as discussed in Ahn) distribute data in frames to end users, the concept of aggregating data streams is a common feature to both – both standards are point-to-multipoint designs. *See* Ex. 1022.

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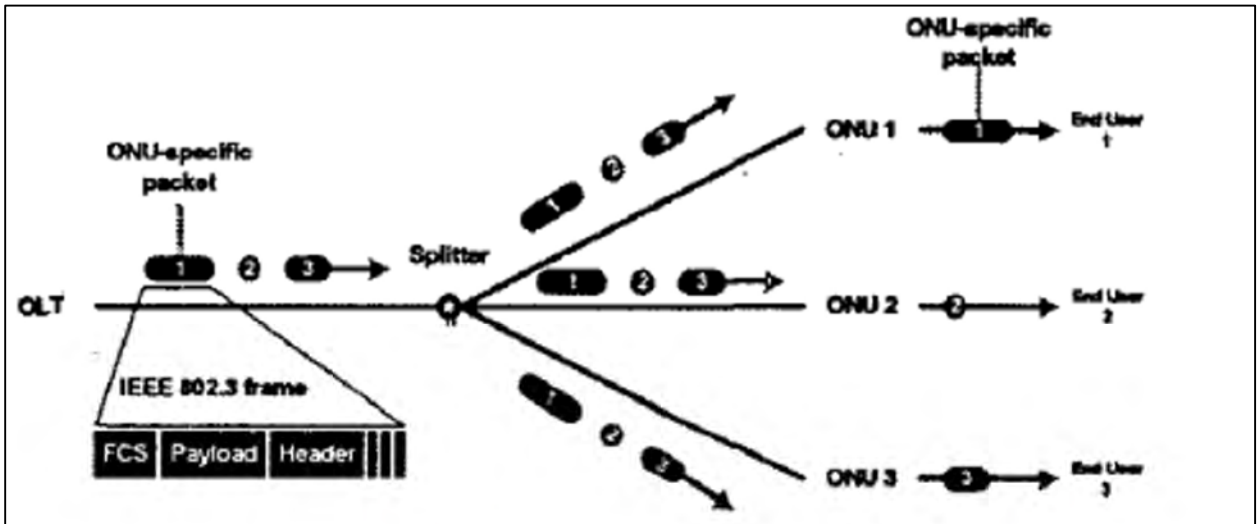
Id. ("Downstream data is broadcast from the OLT to multiple ONUs using variable-length packets, that are a maximum of 1,518 bytes, in accordance with the IEEE 802.3 protocol."). The downstream data is aggregated in the OLT and then sent across the optical distribution network to the ONUs. This is shown in at least Figs. 1, 2, and 5. For example, a data feed is split into 3 separate lines each leading to a different ONU, as shown in FIG. 2, reproduced below. The data feed includes signals aggregated by the OLT for each of the three ONUs. *Id*. When implemented with a VPN as discussed in Ahn, each of the signals are virtually separated and represent private data streams for the respective ONUs. *Id*. Each ONU only processes the packets addressed to it, and discards all others intended for different ONUs, thereby preserving the privacy of the data packets while they are in the aggregated data stream. *Id*.



(FIG. 2) Flow of downstream traffic in EPON

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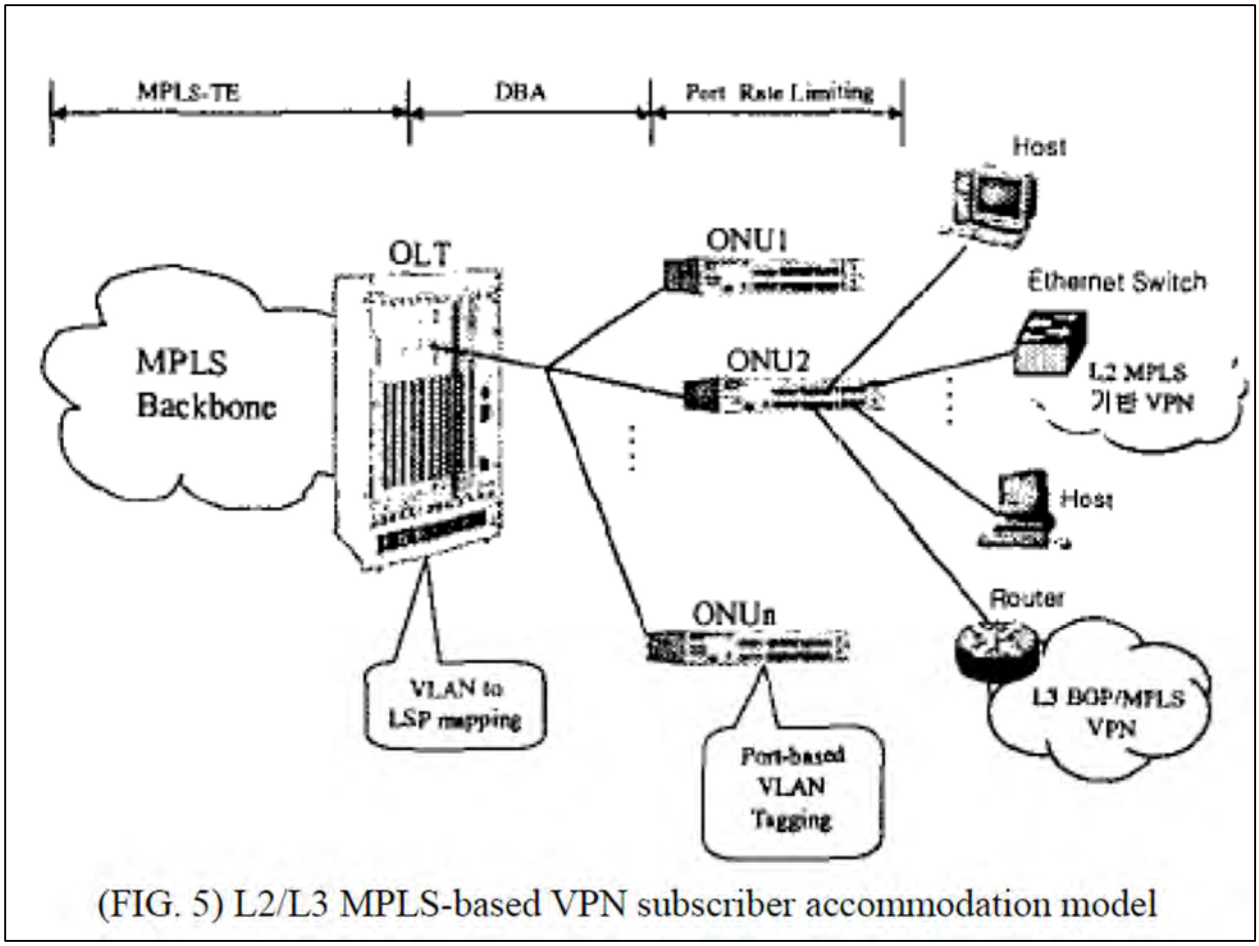

(FIG. 5) L2/L3 MPLS-based VPN subscriber accommodation model

4. [5.C] distributing said common data feed to said plurality of ONUs;

162. As discussed above, both G.984.1 and Ahn disclose that the common data feed is distributed to a plurality of ONUs using the optical splitter that directs identical optical signals along optical lines connected with each of the ONUs. Ex. 1015, 2; Ex. 1013, 21.

163. For example. G.984.1 states that there are a plurality of ONUs that receive a common data feed from the OLT.

164. GPON systems are characterized, in general, by an optical line termination (OLT) system and an optical network unit (ONU) with a passive optical distribution network (ODN) interconnecting them. There is, in general, a one-to-many relationship between the OLT and the ONUs.

165. This general architecture is depicted throughout G.984.1.

I.2 Typical system architectures

Figure I.1 shows a generic GPON system. This is developed more specifically in Figures I.2 to I.7.

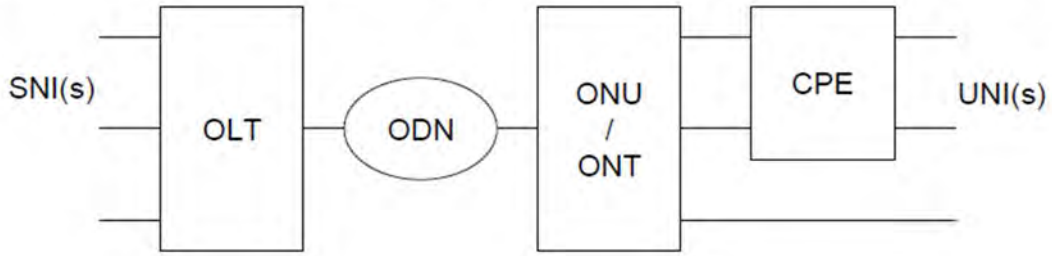

Figure I.1 – Generic GPON system

Ex. 1011, 14.

166. G.984.3 discloses a one-to-many configuration for connecting an OLT to a plurality of ONUs at least in Fig. 5-1.

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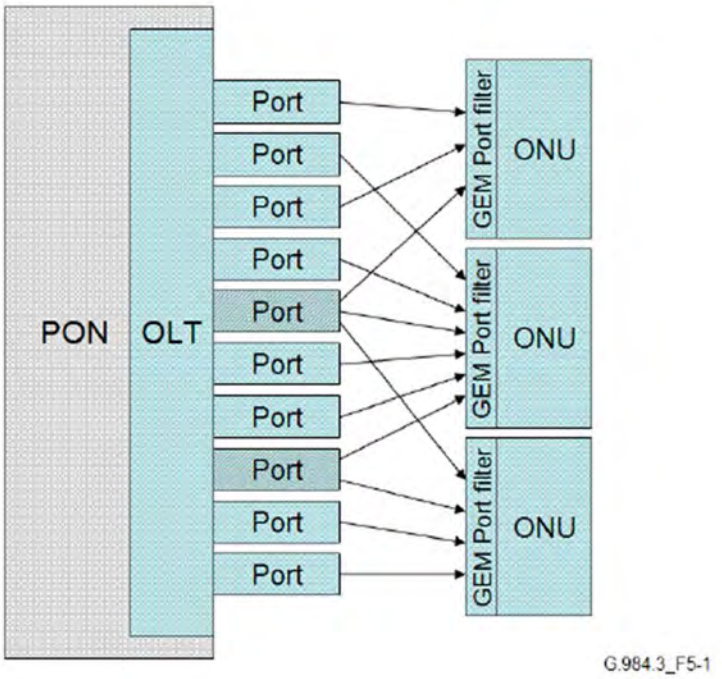
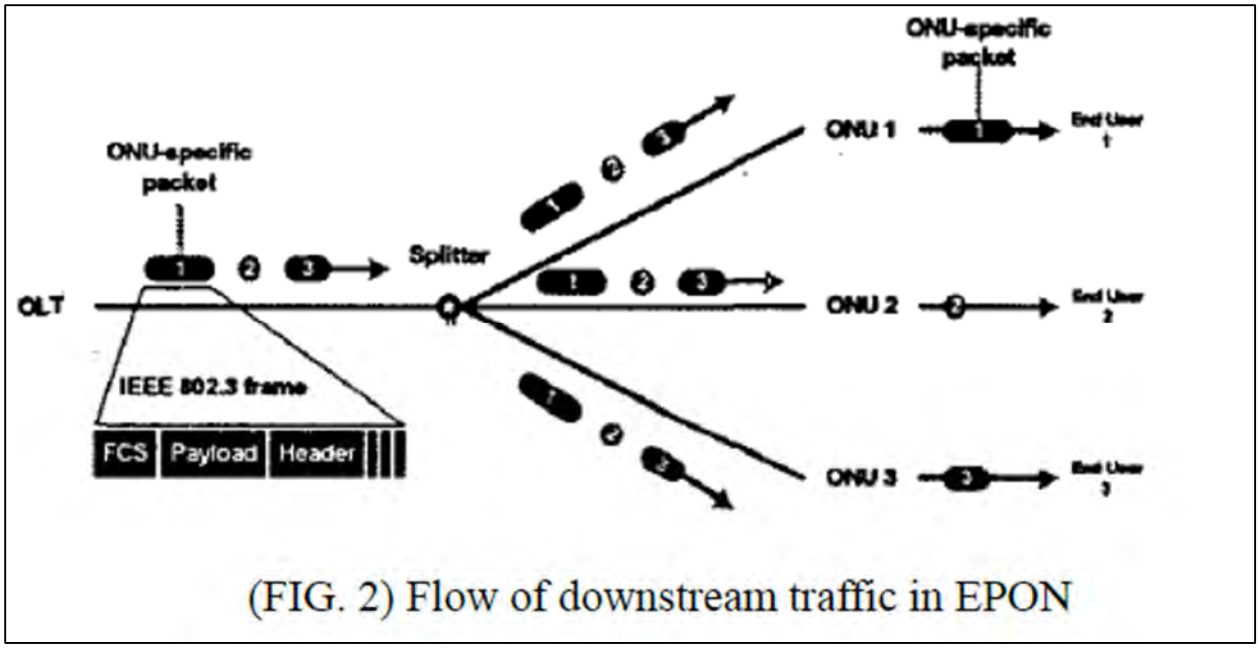


Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

Ex. 1013, 17.

167. As described above, Ahn also discloses and depicts distributing a common data feed to a plurality of ONUs, as shown at least in Figure 2.



(FIG. 2) Flow of downstream traffic in EPON

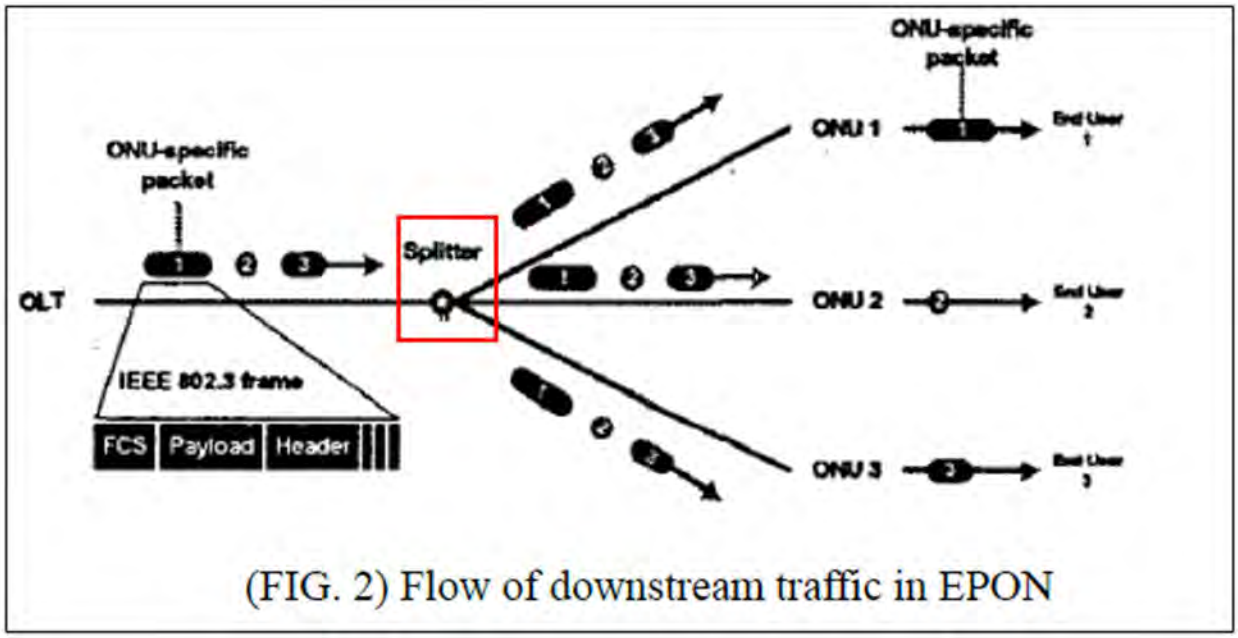
Ex. 1015, 2.

5. [5.D]/[5.E] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;

168. As discussed above, G.984.1, G.984.3 and Ahn discloses an optical splitter that replicates the common data feed and is connected to said plurality of ONUs. *Id.*

169. For example, Fig. 2 (annotated below) of Ahn explicitly depicts and labels the optical splitter for distributing a common data feed to a plurality of ONUs. As is evident from the figure below, optical splitters operate to split light transferred in an input optical signal into more than one output channel – each output channel receives identical signals that are of approximately equal intensity (if the channels do not include signal amplifiers, the signal on each output channel will have a lower

intensity than the input signal). The splitter itself is incapable of distinguishing between different signals or destinations because it does not include any processors therein, and so the recipient devices connected to each output channel must identify and discard data packets not intended for them.



(FIG. 2) Flow of downstream traffic in EPON

170. Ahn further explains that "[t]he passive equipment of Ethernet-PON located in an ODN comprises single-mode optical fiber, passive optical fiber splitters/couplers, connectors, and the like." Ex. 1015, 4. As shown in Fig. 2 of Ahn, "the traffic from the splitters is split into three signals, and ***each signal then delivers the packets*** that are being ***sent to all the ONUS***." *Id.*, 2 (emphasis added). Fig. 2 depicts, for example, that packets 1, 2, and 3 are each replicated and distributed to ONU1, ONU2, and ONU3.

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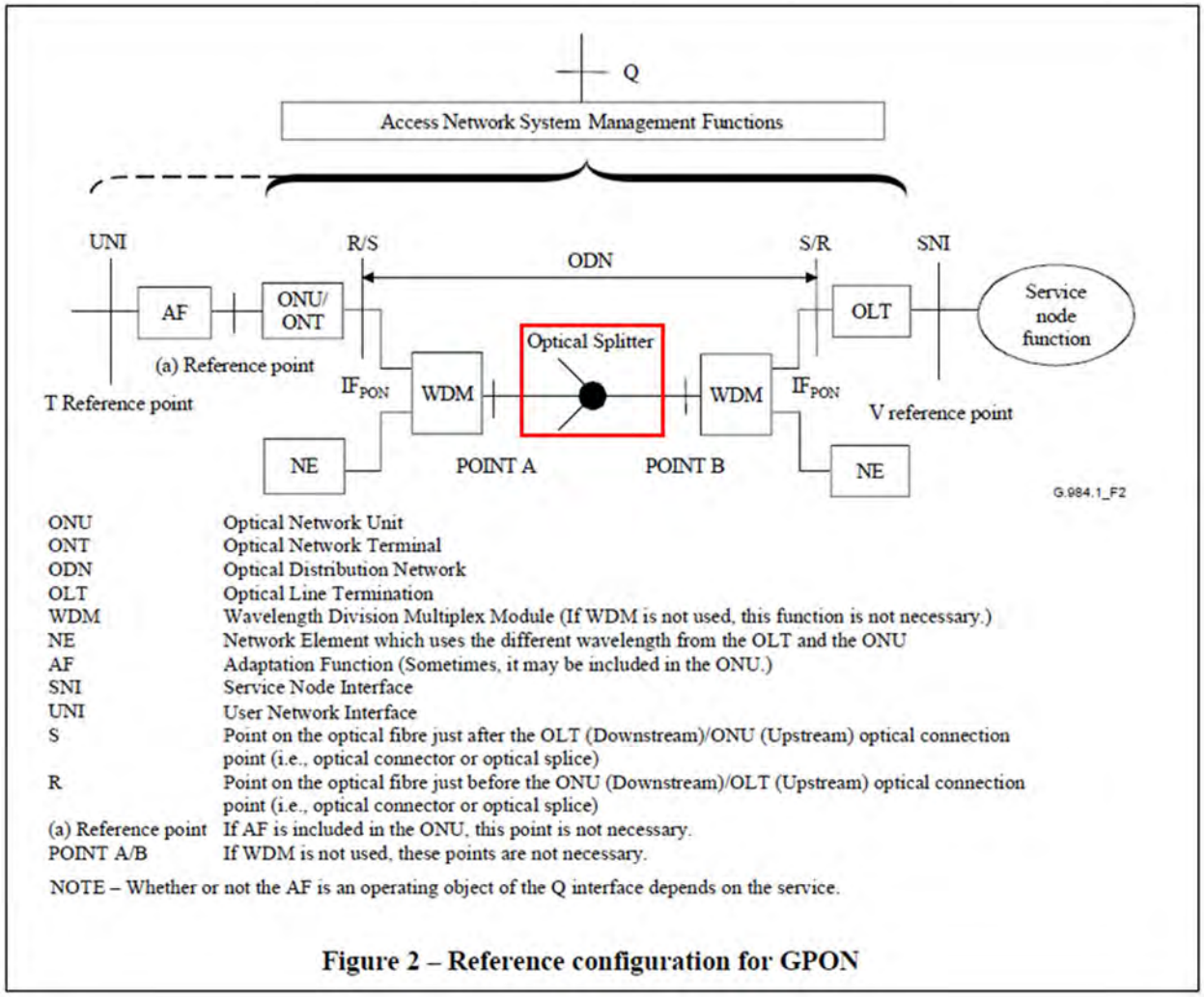
171. Similarly, Figure 2 of G.984.1 (annotated below) depicts the optical splitter.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

172. The splitter and the allowable split ratio is further discussed within G.984.1. *Id*., 13. For example, it teaches that "split ratios of up to 1:64 are realistic for the physical layer, given current technology." *Id*. Here, the ratio is the number of ONU's (64) that can be connected with a single (1) OLT port. The "split" in "split ratio" refers to the use of optical splitters, that replicate the data feed to all of the

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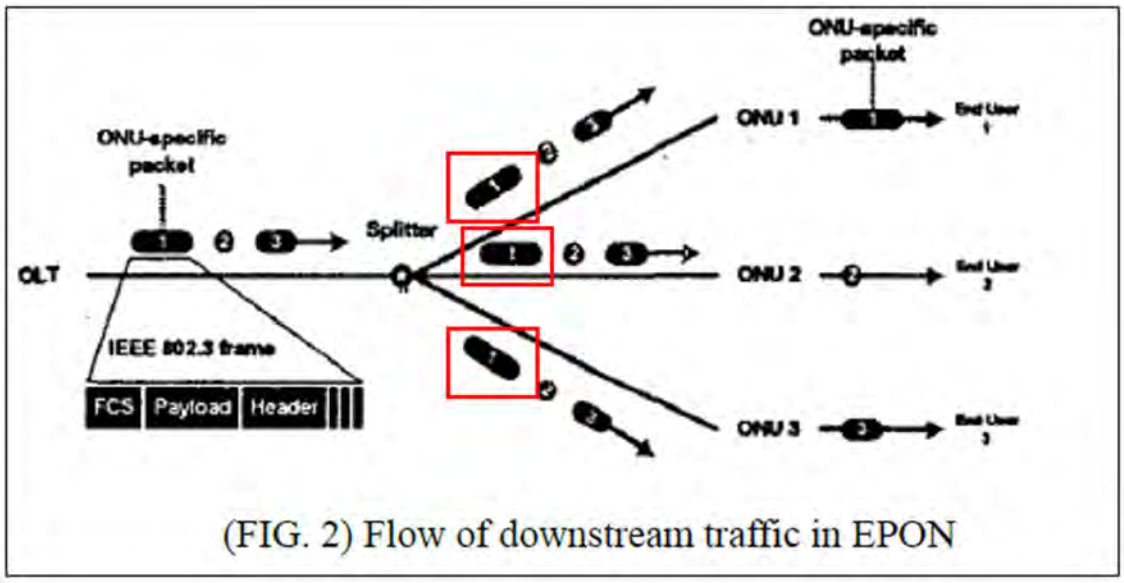
ONUs connected with the splitter. *Id*. ("a larger split ratio implies greater optical splitting").

173. G.984.3 confirms the use of optical splitters to distribute signals from the OLT to a plurality of ONUs. Ex.1013, 20.

6. [5.F] delivering said common data feed to said plurality of ONUs;

174. As discussed above, the optical splitter of G.984.3 and Ahn's optical splitter is connected with optical lines connected with each respective ONU, so that the common data feed is replicated and delivered to each of the plurality of ONUs. *Id*. Ahn's figure 2 (annotated below) depicts delivering the common data feed comprising packets 1, 2, and 3 to a plurality of ONUs—ONU1, ONU2, and ONU3.



(FIG. 2) Flow of downstream traffic in EPON

Ex. 1015, 2.

175. Ahn further explains that:

(FIG. 2) and (FIG. 3) show the downstream data transmission processing method from OLT to multiple ONUs, and the upstream data transmission method from multiple ONUs to OLT in an Ethernet-PON system. Downstream data is broadcast from the OLT to multiple ONUs using variable-length packets, that are a maximum of 1,518 bytes, in accordance with the IEEE 802.3 protocol.

Ex. 1015, 2.

176. Similarly, Figure 2 of G.984.1 depicts the optical distribution including an optical splitter provided to delivere a common data feed to a plurality of ONUs. Although only one ONU/ONT is shown, the optical splitter includes multiple output channels (shown as the lines extending outward from the left side of the optical splitter), and a POSITA would have understood that these lines represent multiple outputs to multiple ONUs/ONTs – each may have a connection infrastructure identical to the one shown in Figure 2.

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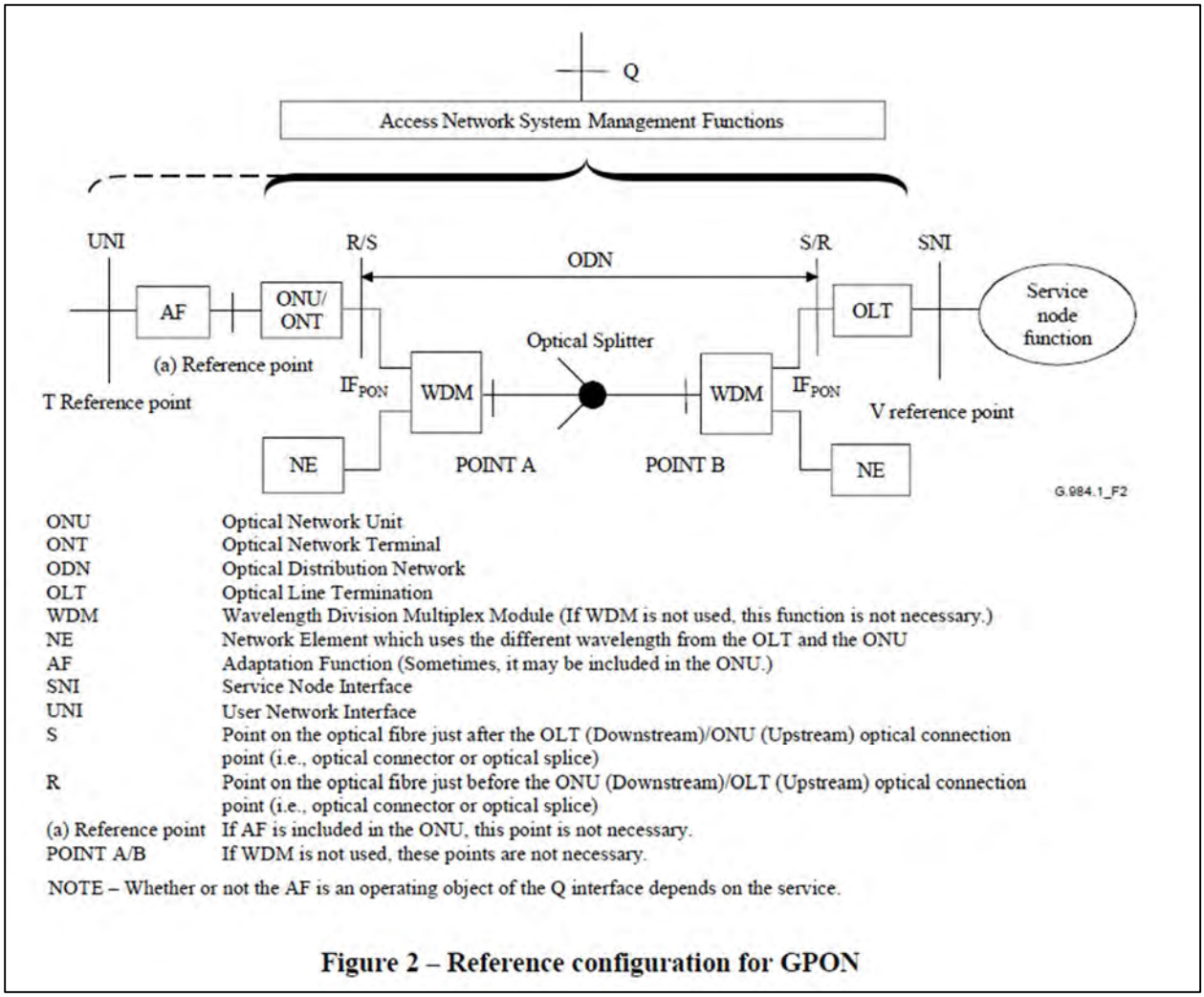

ONU	Optical Network Unit
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ODN	Optical Distribution Network
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WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
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SNI	Service Node Interface
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(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

177. As discussed, G.984.1 contemplates that at least 64 ONUs can be connected to a single OLT port. *Id.*

7. [5.G] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;

178. The ’142 patent explains that “[e]ach ONU 330, 332, 334 is operated so that it utilizes the VLAN-tagging to select those of the incoming ethernet frames

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assigned to the particular tenant, and then removes the encryption from the selected ethernet frames." Ex. 1001, 7:22-25.

179. G.984.1 and G.984.3 discloses limitation [5.G]. GPON, as described in G.984.1 and G.984.3, utilizes the data transport scheme known as GPON Encapsulation Method (GEM), to send data from the OLT to ONUs. Ex. 1013, 15-16. According to G.984.3 "GEM provides a connection-oriented, variable-length framing mechanism for transport of data services over the passive optical network (PON) and is independent of the type of the service node interface at the OLT as well as the types of UNI interfaces at the ONUs." *Id*. G.984.3 further explains that "IP packets are carried directed in the GEM frame payload." *Id.*, 128.

180. G.984.3 further explains that a given ONU only extracts the GEM frames that have been specifically addressed to that ONU despite the fact that the ONU receives the GEM frames for other ONUs that are part of the common data feed.

> In the downstream direction, the traffic multiplexing functionality is centralized. The OLT multiplexes the GEM frames onto the transmission medium using GEM Port-ID as a key to identify the GEM frames that belong to different downstream logical connections. Each ONU filters the downstream GEM frames based on their GEM Port-IDs and processes only the GEM frames that belong to that ONU.

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Ex. 1013, 17.

181. As such, G.984.3 teaches that at least one of the ONUs extracts the virtually separated data stream that includes IP data packages from the common data feed that is received over the ODN.

182. As discussed above, once the common data feed is received at an ONU, Ahn discloses that said at least one of said plurality of ONUs extract said at least one virtually separated private data stream including said IP data packages from said common data feed. Ex. 1015, 2. Ahn explains that "each ONU processes only the packets addressed to it, discarding all others intended for different ONUs. For example, ONU1 receives Packets 1, 2, and 3; however only Packet 1 is delivered to User 1 [of FIG. 2]." *Id*. The "Packets" are the IP data packets received from the OLT, which were forwarded from the IP backbone network (from the first PE). *Id*. Ahn, therefore, also teaches that at least one of the ONUs extracts the virtually separated data stream that includes IP data packages from the common data feed that is received over the ODN.

8. [5.H] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.

183. The '142 patent explains that once ONU-specific data feeds are decrypted, they are "then made available 340, 342, 344 for the tenant's IP/ethernet end-user equipment." Ex. 1001, 7:27-29.

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184. G.984.1 and G.984.3 discloses [5.H]. As discussed above in [5.G], G.984.1 and G.984.3 discloses that a given ONU extracts only the IP packages from a GEM frame where the GEM port ID matches the ONU. The purpose of extracting that IP package is to send the IP package (in the at least one virtually separated private data stream) from the at least on ONU to the at least one private user device that is connected to that ONU of the plurality of user devices, while discarding any data that is intended for user devices connected to different ONUs. The purpose of an access network, such as the one described by G.984.1, is to provide access to user devices to a wider network, such as the internet or other IP networks. G.984.1 teaches a "User Network Interface" that exists downstream of an ONU, such as gigabit ethernet. Ex. 1011, 19. This is depicted in Fig. I.1.

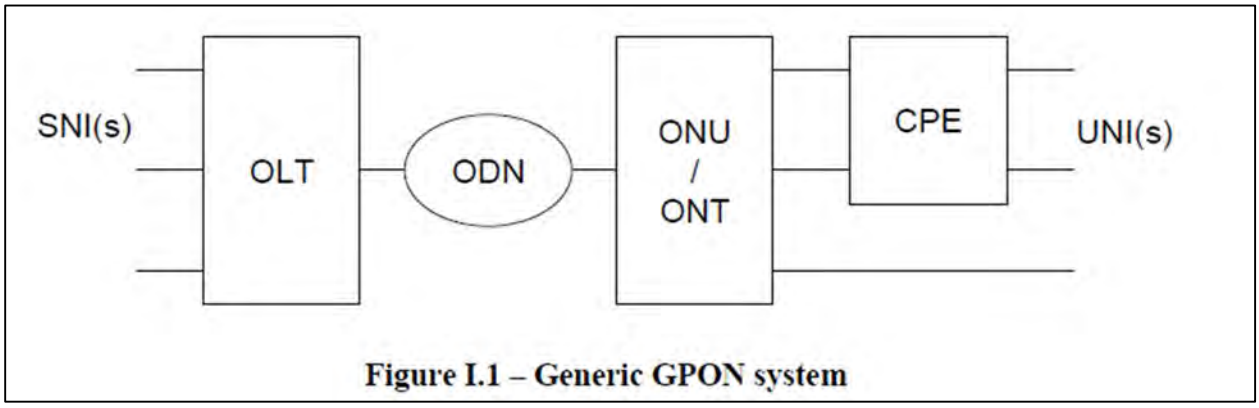

Figure I.1 – Generic GPON system

Id., 20.

185. G.984.1 further describes that "[i]n the ONT, Ethernet frames as defined in [b-IEEE 802.3] are extracted from the TC layer. In some ONTs, the Ethernet layer is quite abbreviated and little processing is done on the frames from

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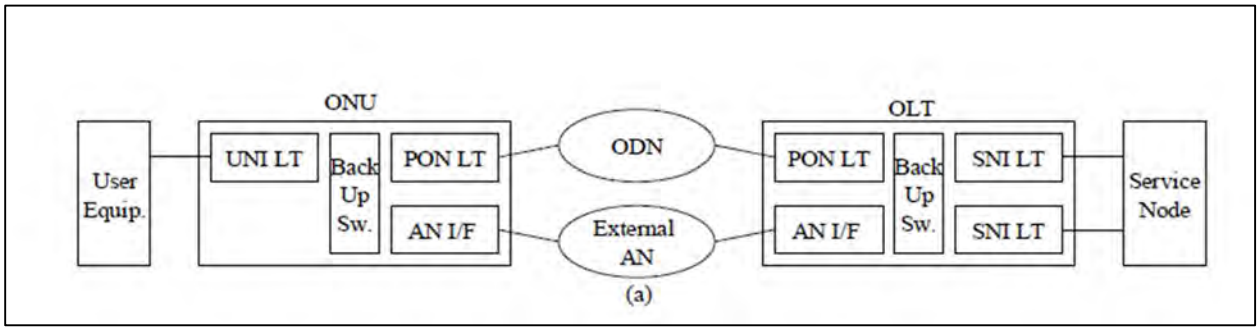
their reception on the GPON interface to their transmission on the UNI." *Id*. G.984.1 further notes that "[i]n some ONTs, some sort of VLAN processing is done, as defined in the IEEE 802.1-series of standards." G.984.1 further explains that this can be to identify the specific user by a VLAN-ID.

> This typically involves adding tag(s) in the upstream, and removing tag(s) in the downstream, for the purpose of identifying each user/service packet via their VLAN-ID. However, this is not necessary in all cases, since the PON itself has the GEM port-ID mechanism for such identification.

Id.

186. G.984.1 further confirms that user equipment is downstream of an ONU.



Ex. 1011, 34.

187. As discussed above, Ahn also discloses this limitation. Ahn explains that an ONU "receives" a plurality of data streams as a part of an aggregated common data feed, extracts only the data feed that is addressed to it, and then sends

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the extracted data packet (i.e., the at least one virtually separated private data stream including said IP data packages) to a private user device of an end user (User 1, in FIG. 2, above), which is one of a plurality of end users (and their corresponding devices), as shown in FIG. 2 of Ahn. Ex. 1015, 2.

D. Claim 6 - The method of claim 5, wherein said at least one of said plurality of ONUs provides services to at least one private user of a plurality of users.

188. As discussed in reference to [5.H], the '142 patent explains that services (e.g., Internet, public switched telephone networks, and broadcast/cable television) are provided to a tenant (of a plurality of tenants, as shown in Figure 4 of the '142 patent). Ex. 1001, 4:23-26, 7:25-29.

189. G.984.1 discloses this claim, explaining that services are provided, according to a service node interface to an OLT that provides the services to the end user at the ONU. More specifically, Table I.2 describes UNIs and services that are provided to downstream users.

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Examples of UNIs, physical interfaces and services that they provide are shown in Table I.2.

Table I.2 – Examples of UNI and services

UNI (Note 1)	Physical interface (Note 2)	Service (Note 3)
10BASE-T ([b-IEEE 802.3])	–	Ethernet
100BASE-TX ([b-IEEE 802.3])	–	Ethernet
1000BASE- T ([b-IEEE 802.3])	–	Ethernet
[b-ITU-T I.430]	–	ISDN (BRI)
[b-ITU-T G.703]	PDH	DS3, ATM, E1, E3
[b-ANSI T1.102], [b-ANSI T1.107]	PDH	T1, DS3
NOTE 1 – There are many other services accommodated in GPON, but those services do not have specified UNIs. NOTE 2 – Each item in the "physical interface" column is illustrated by the corresponding entry in the "UNI" column. NOTE 3 – The column labelled "service" shows which services can be supported by the physical interface.		

190. This is also illustrated in G.984.1's Figure 2, reproduced below, which shows that the PON connects the user network interface to a service node function.

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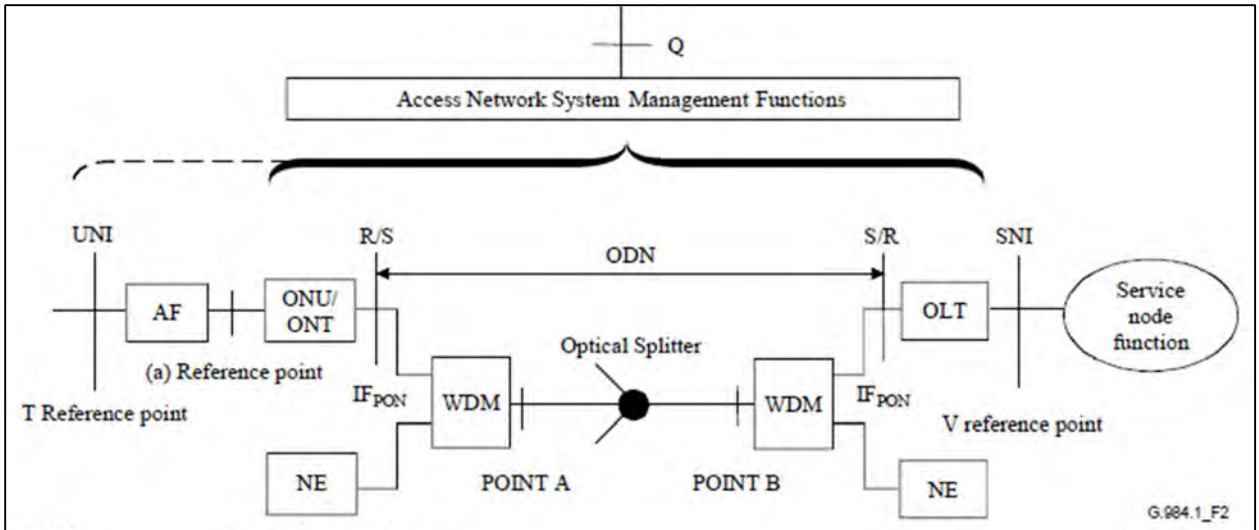

ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
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(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

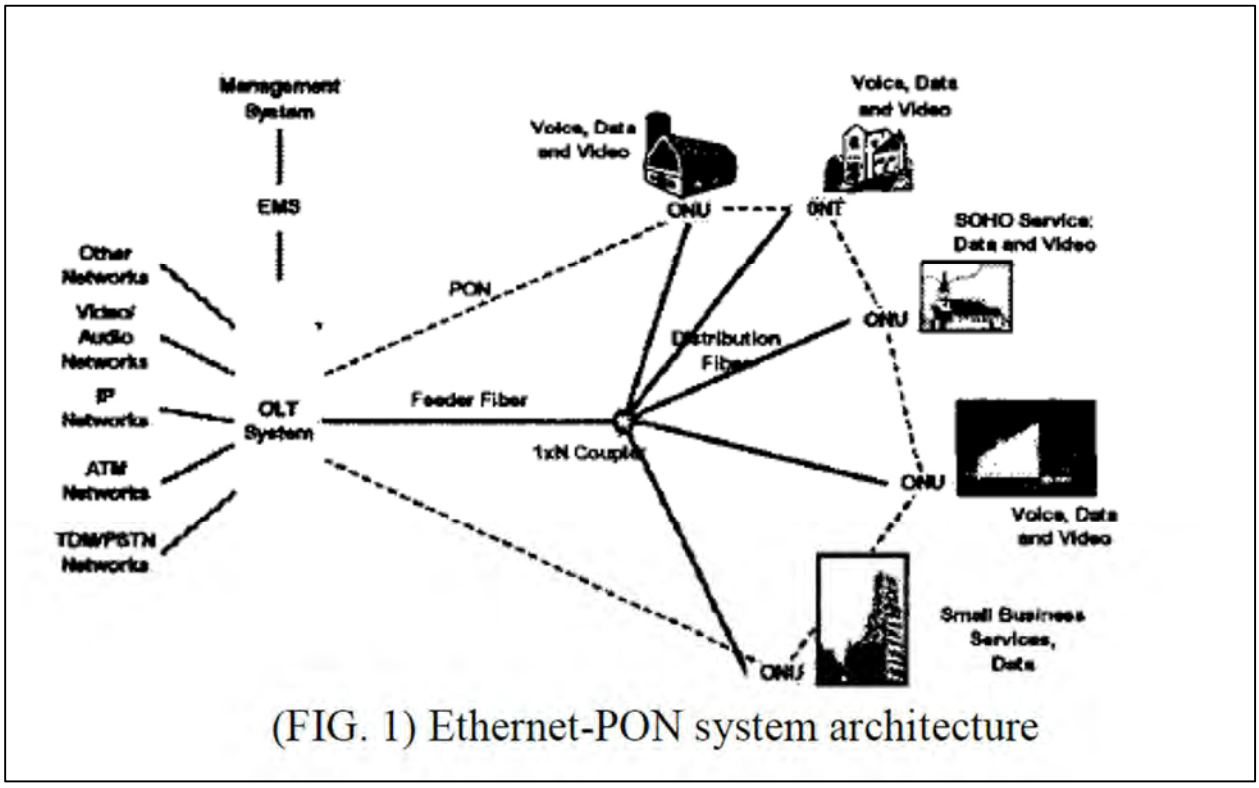
NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

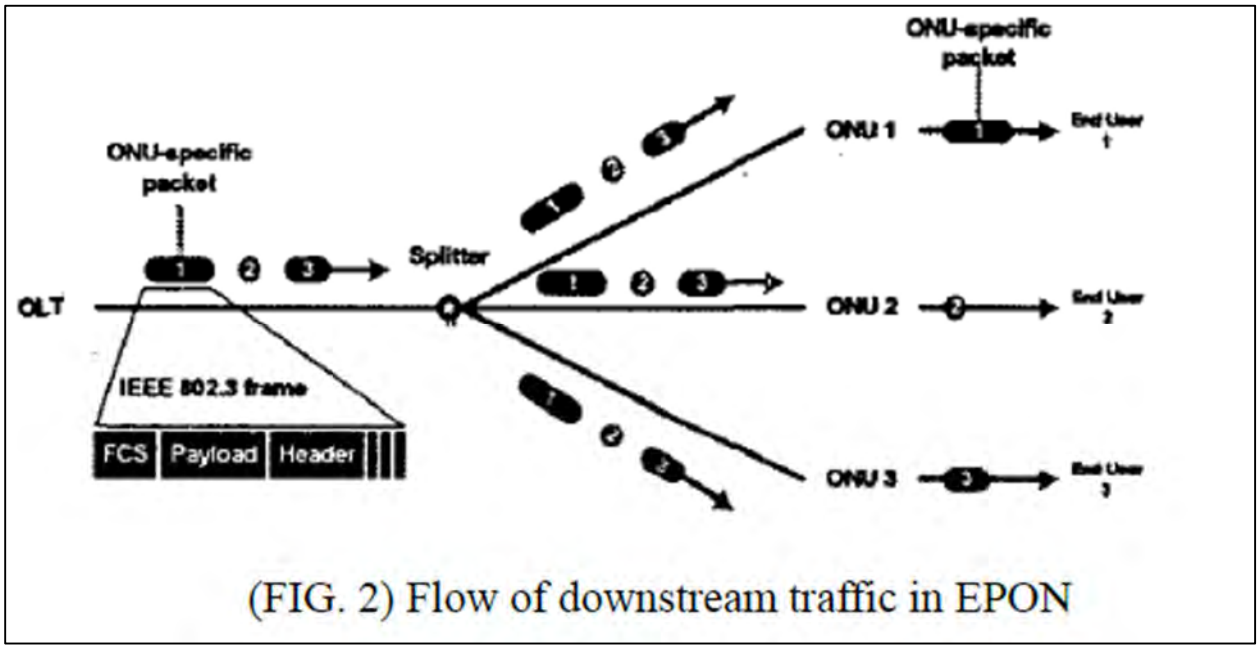
191. As a result, the services are provided to said at least one of said plurality of ONUs, which provides the services to the at least one private user connected to the ONU, of the plurality of users.

192. Ahn also discloses this claim, explaining that an ONU of a plurality of ONUs services at least one private user of a plurality of private users by passing data packets to the private user's device. This is shown in Ahn's FIG. 1 and FIG. 2, shown

below. The services can include services from the video/audio networks, IP networks, ATM networks, and others.



(FIG. 1) Ethernet-PON system architecture



(FIG. 2) Flow of downstream traffic in EPON

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E. Claim 7 - The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream comprising said IP data packages to said PON OLT.

193. The '142 patent states that "an aggregation switch [is] referred to as an Optical Line Terminal (OLT)," and is depicted in Fig. 2 as element "146." Ex. 1001, 4:34-38.

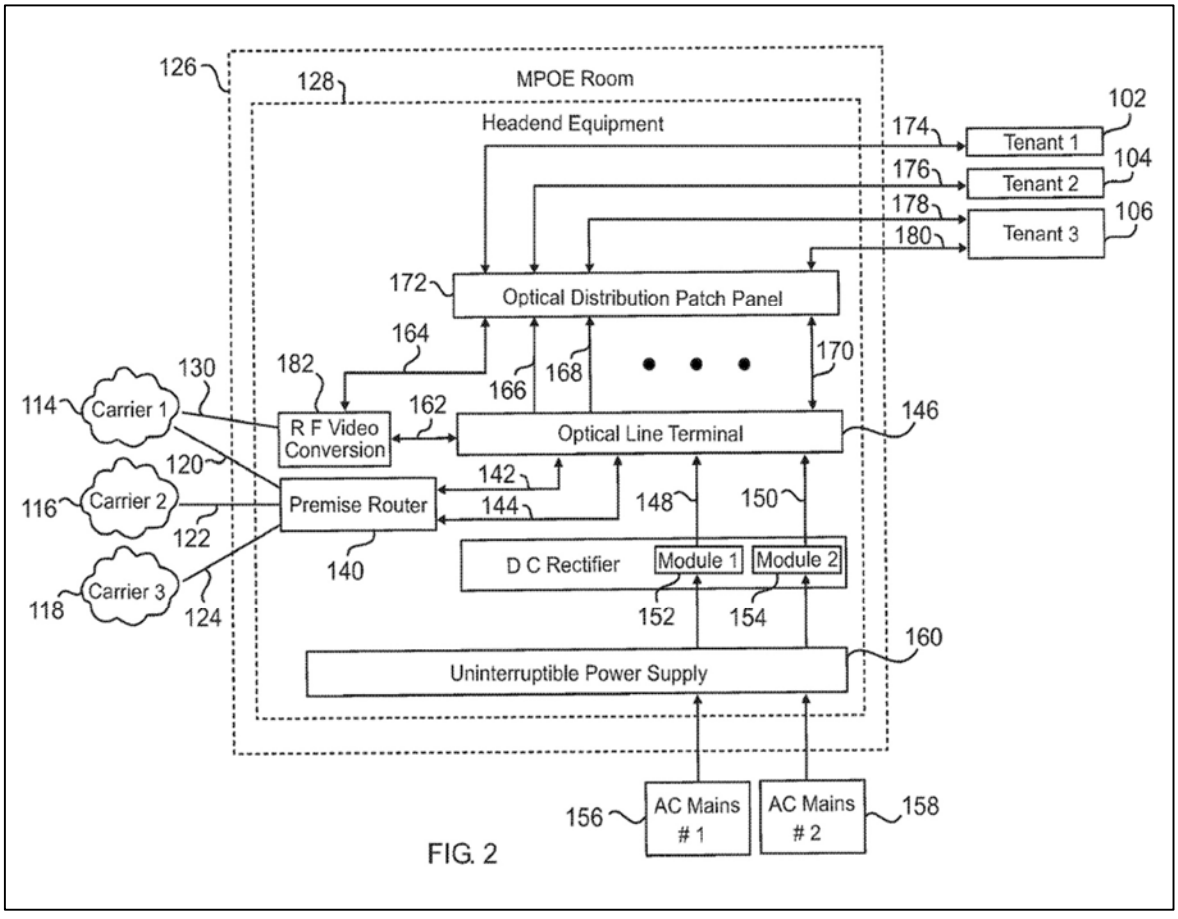

FIG. 2

194. G.984.1 discloses this claim, by explaining that an OLT includes an aggregation switch and a PON Line Terminal (PON LT) in serial connection with the aggregation switch. Ex. 1011, 14. G.984.1 discloses switches located between a

service node interface and PON Line Termination (PON LT), to be connected in series with the PON Line Termination. *Id*. The switch delivers the plurality of data streams from the service node (which includes the virtually separate private data stream containing the IP data packages, received from the service node, as discussed above).

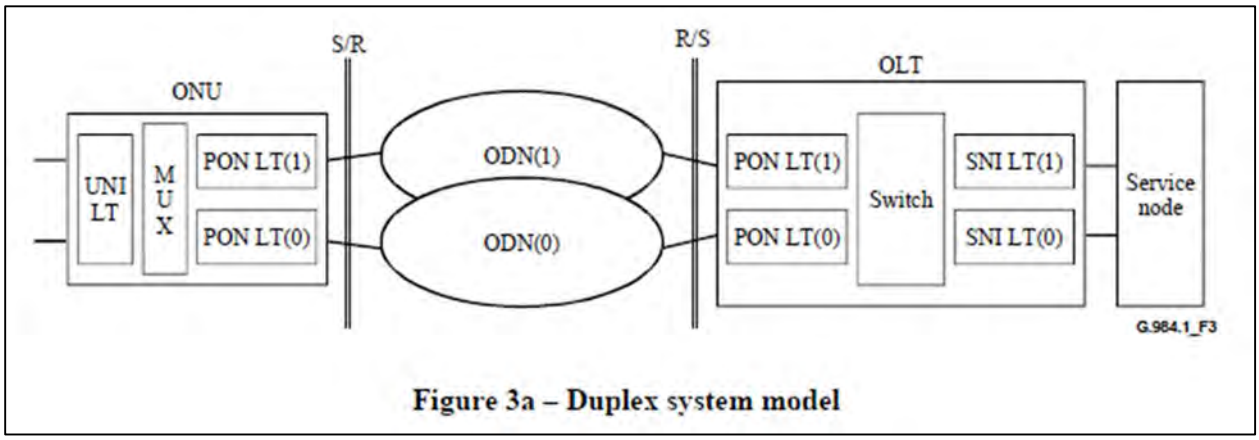

Figure 3a – Duplex system model

195. While Fig. 3a depicts the PON LT, the switch, and the SNI LT as part of the "OLT," a POSITA would understand that the PON LT is functioning as the OLT of Claim 7. This is further shown by Fig. 2 of G.984.1, which depicts the SNI as outside of the OLT.

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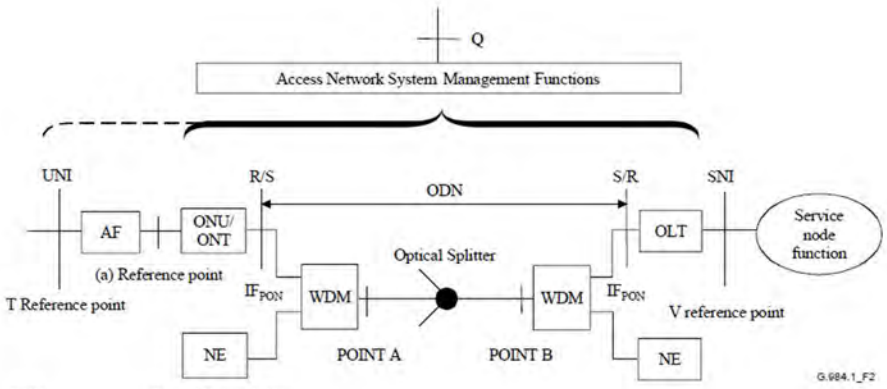

ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

196. Regardless, the '142 patent contemplates that the aggregation switch and the OLT could be contained within the same physical device. Ex. 1001, 4:34-44. And Fig. 3a of G.984.1 (above) shows that a switch that is serially connected between the device that is performing the digital to optical conversion, the PON LT, and the broader network, which would include a PON interface router. *See* Claim [5.A].

F. Claim 8

1. [8.PRE] A digital network communication method comprises:

197. To the extent the preamble is limiting, a POSITA would have understood the G.984.1, G.984.3, RFC 4364, and Ahn combination teaches this limitation for at least the same reasons as discussed in reference to Claim 5.

198. *See* limitation [5.pre].

2. [8.A] receiving at a passive optical network (PON) optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices;

199. See limitation [5.A]. The only difference between Claim [8.A] and [5.A] is that [5.A] includes a requirement that the OLT receive the at least one private data stream from a PON interface router. Claim [8.A] does not include this additional limitation and is therefore broader than Claim [5.A]. Therefore, for those reasons discussed in reference to claim limitation [5.A], G.984.1, G.984.3, RFC 4364, and Ahn disclose the limitations of [8.A].

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3. [8.B] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;

200. See Limitation [5.B].

4. [8.C] distributing said common data feed to said plurality of ONUs;

201. See limitation [5.C].

5. [8.D]/[8.E] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;

202. See limitations [5.D]/[5.E].

6. [8.F] delivering said common data feed to said plurality of ONUs;

203. See limitation [5.F].

7. [8.G] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;

204. See limitation [5.G].

8. [8.H] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.

205. See limitation [5.H].

G. Claim 9 - The method of claim 8, wherein said at least one of said plurality of ONUs provides services to at least one private user our [*sic*] of plurality of users.

206. See Claim 6.

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H. Claim 1

1. [1.PRE] A digital data network communication method comprises:

207. To the extent the preamble is limiting, a POSITA would have understood the G.984.1, G.984.3, RFC 4364, and Ahn combination teaches this limitation.

208. *See* limitation [5.pre].

209. While claims 5 and 8 focus on providing data over a PON to an end user (e.g., from a network), Claim 1 describes an end-to-end process whereby data is first uploaded to the network (using a PON), transmitted across the network, and then provided to an end user via a PON. The steps for providing data to the end user via a PON are analogous to those recited in claims 5 and 8. As discussed below, the remaining limitations, including those limitations discussing the upload of data to a network using a PON and transferring data across a network are also nothing new.

2. [1.A] accepting a plurality of data streams into a primary passive optical network (PON) interface router, interconnected with a secondary PON interface router serving a plurality of user devices through a plurality of optical network units (ONUs);

210. G.984.1, G.984.3, RFC 4364, and Ahn disclose this limitation.

211. The ’142 patent illustrates this limitation in Figure 2, reproduced below, which shows the “headend equipment 128 receives the plurality of telecommunications service carrier lines 120, 122, 124 from the separate carrier

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providers 114, 116, 118." Ex. 1001, 4:45-47. The signals received can include "VLAN-tagged voice, video and data content traffic connected to the Optical Line Terminal (OLT) 146 through an uplink 142 that provides primary communication." *Id*., 4:57-59.

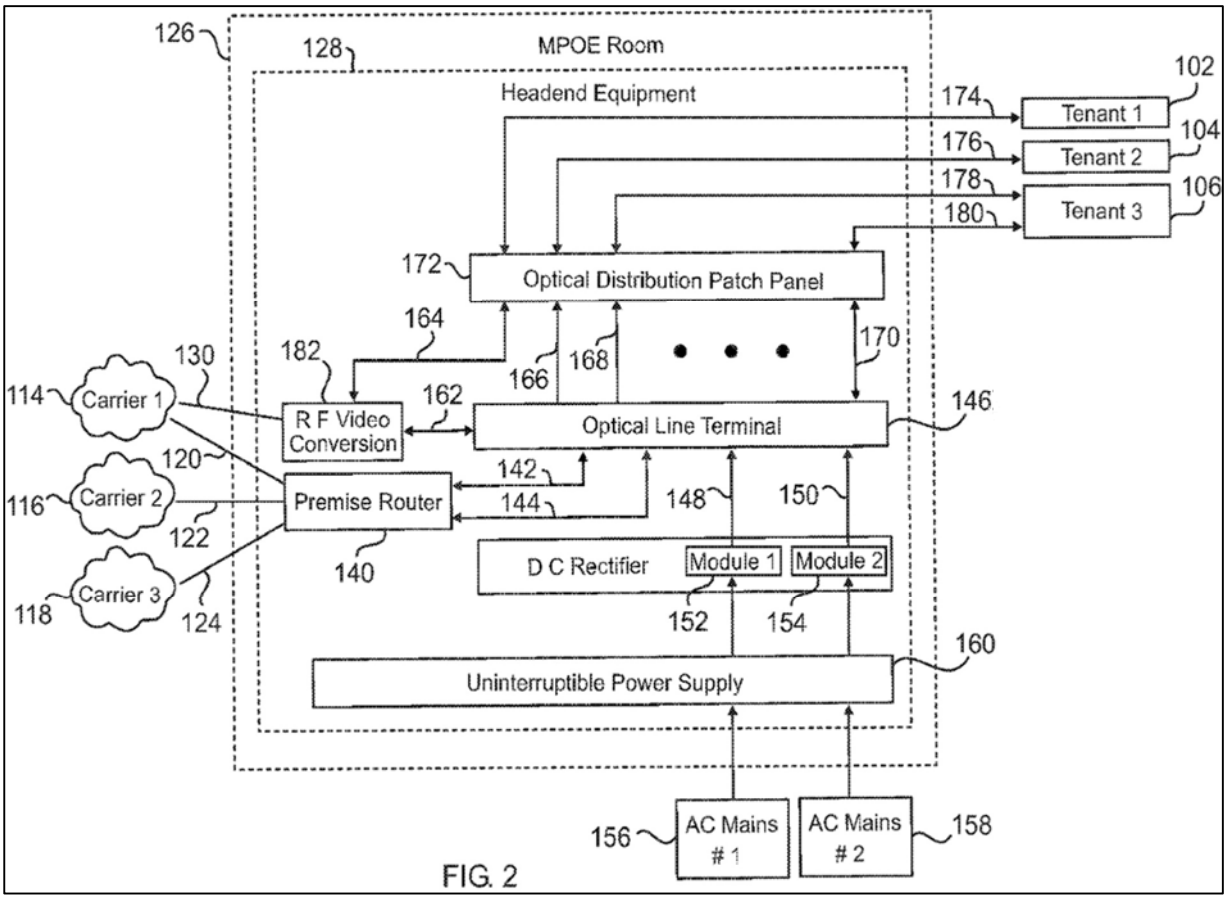

FIG. 2

212. G.984.1 describes the architecture of "an optical line termination (OLT) system and an optical network unit (ONU) or optical network termination (ONT) with a passive distribution network (ODN) interconnecting them" (Ex. 1011, 7) therefore, G.984.1 describes the devices for connecting an end user (using an ONU) to a network, such as an IP backbone. Those devices (e.g., ONUs connected with an

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OLT that connects with a service network interface (SNI) are configured for connecting a plurality of users (using a plurality of ONUs) to the network. The functionality of the network (e.g., IP backbone) is nothing new.

213. RFC 4364 discloses limitation [1.A]. RFC 4364 explains that Service Providers' edge routers (PE routers) accept a plurality of data streams, for example, from a plurality of customers' edge routers (CE routers). Ex. 1014, 12, 23 (describing that multiple CEs are be attached to a PE, and explaining how to forward data received from a CE). The data streams can be routed from one CE router, to a PE router (*Id.*, 23), through the IP backbone to a second PE router (e.g., by "tunneling") (*Id*., 24), which provides the data stream to a second CE device. *Id.*, 25. The first PE router in this chain is claim 1's "primary passive optical network (PON) interface router" when implemented with a PON, and the second PE router connected with an intended destination of the data stream is claim 1's "secondary PON interface router" that services a plurality of ONUs. *Id*., 24.

214. As Ahn demonstrates, a POSITA would have been motivated to combine RFC 4364 with G.984.1 and G.984.3 to implement VRF on a PON, so that each of the PEs disclosed in RFC 4364 would have been implemented as PON interface routers. Specifically with respect to limitation [1.A], a POSITA would have recognized that G.984's purpose is to standardize a GPON that connects end users to a network such as the IP backbone discussed in RFC 4364.

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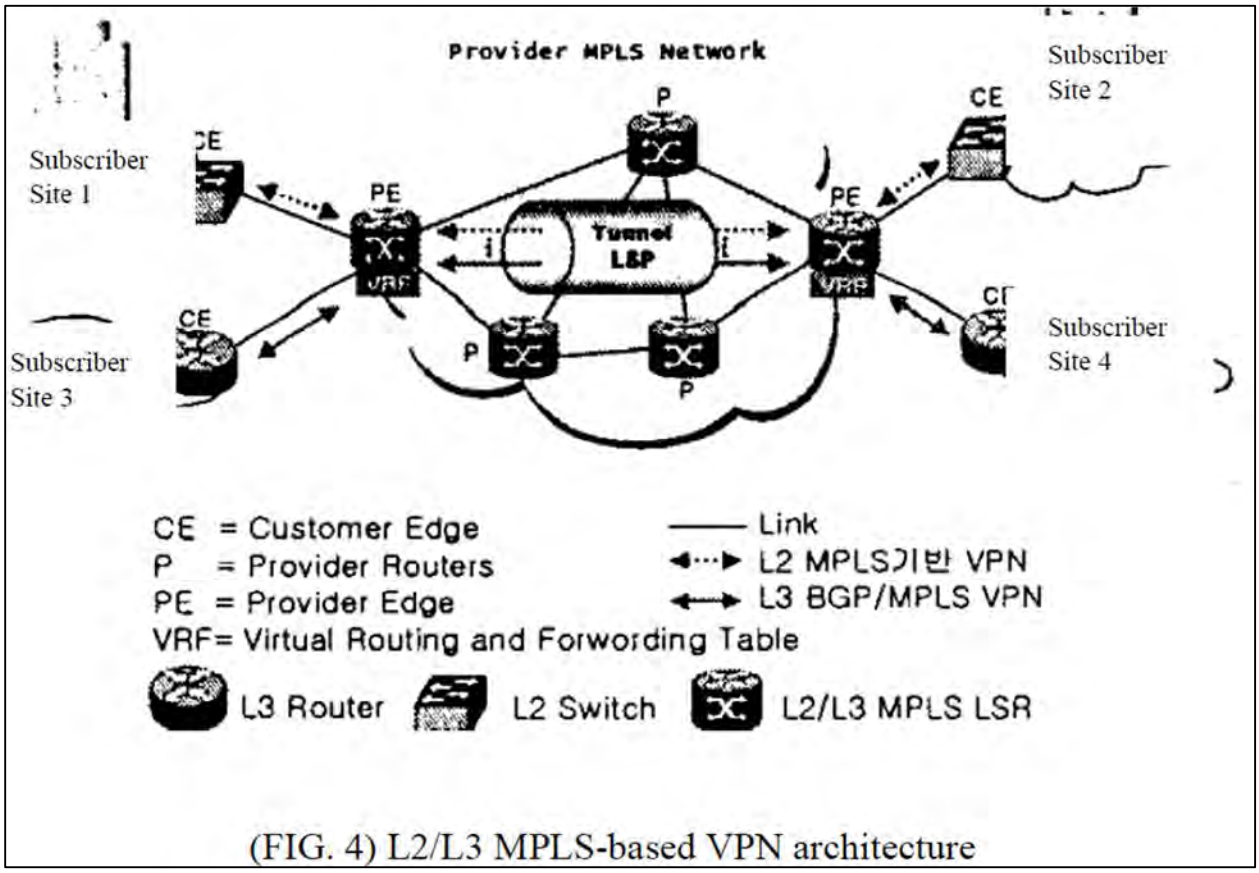
215. Ahn also discloses limitation [1.A] and discusses implementing a VRF over a PON. Ahn discloses an architecture that relies on multiple routers (labeled PE and P in Fig. 4 below). Ex. 1015, 3.



(FIG. 4) L2/L3 MPLS-based VPN architecture

216. Ahn explains that PON routers (such as those discussed in G.984.1-3) can be used to implement an MPLS-based VPN service (such as that discussed in RFC 4364). A POSITA reviewing Ahn would have known to review the most prevalent standards and recommendations for PONs (e.g., GPONs, as discussed in G.984.1-3) and VRFs (e.g., as discussed in RFC 4364). Ahn also teaches that these routers interconnect to a PON comprising an OLT that is connected by fiber optics and passive splitters to a plurality of ONUs. Specifically, Ahn describes an OLT

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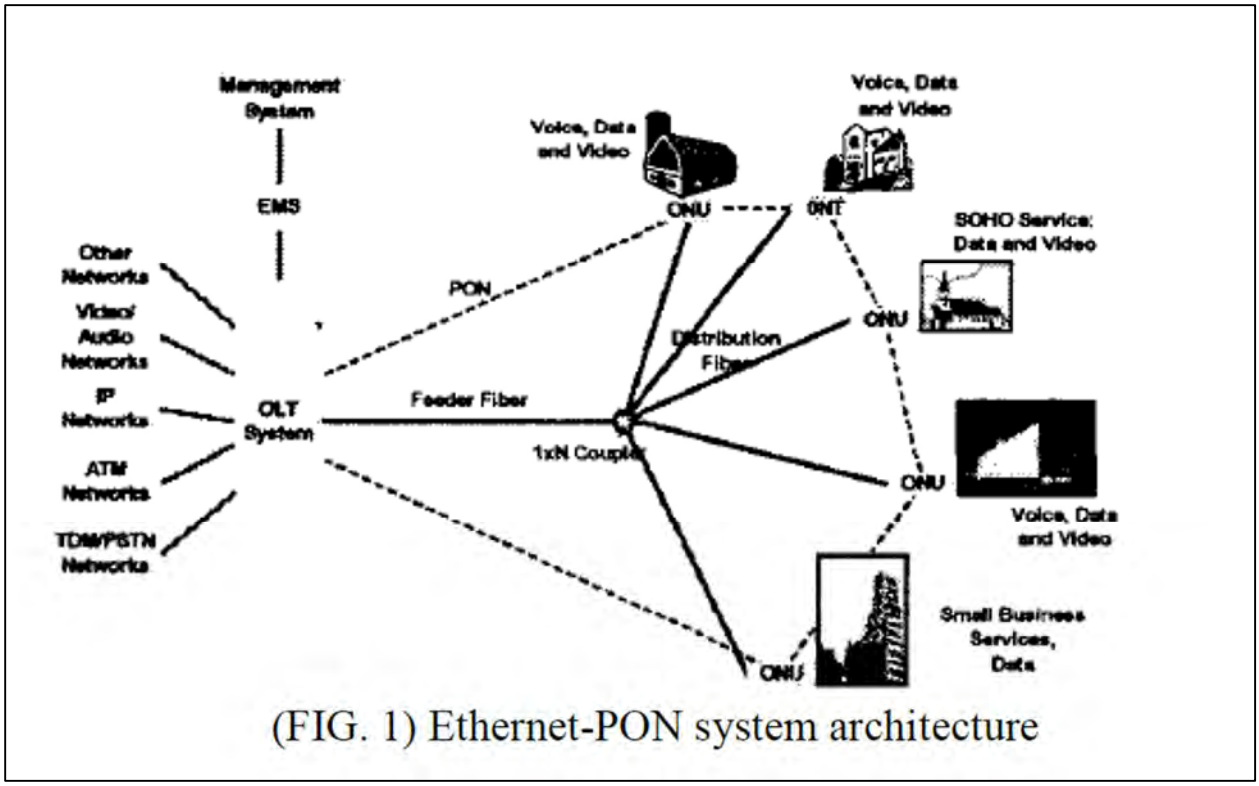
subsystem of a PON as being located at the central office, which receives data streams from a PON router, such as a PE router. Ex. 1015, 2-3. Either an ONU or ONT is located at the curb, within buildings, or inside homes (the ONUs and ONT services a plurality of user devices). *Id.*, 2. Ahn explains that the OLT accepts a plurality of data streams (e.g., as shown in Ahn's FIG. 1, below), including "Other Networks," "video/audio networks," "IP Networks," "ATM Networks," and "TDM/PSTM Networks." *Id*.



(FIG. 1) Ethernet-PON system architecture

217. Ahn discusses implementing the MPLS-based VPN over a PON, explaining that routing of multiple data traffic signals is performed by the OLT. *Id*., 3. Ahn also uses the same terminology as RFC 4364 when discussing the various

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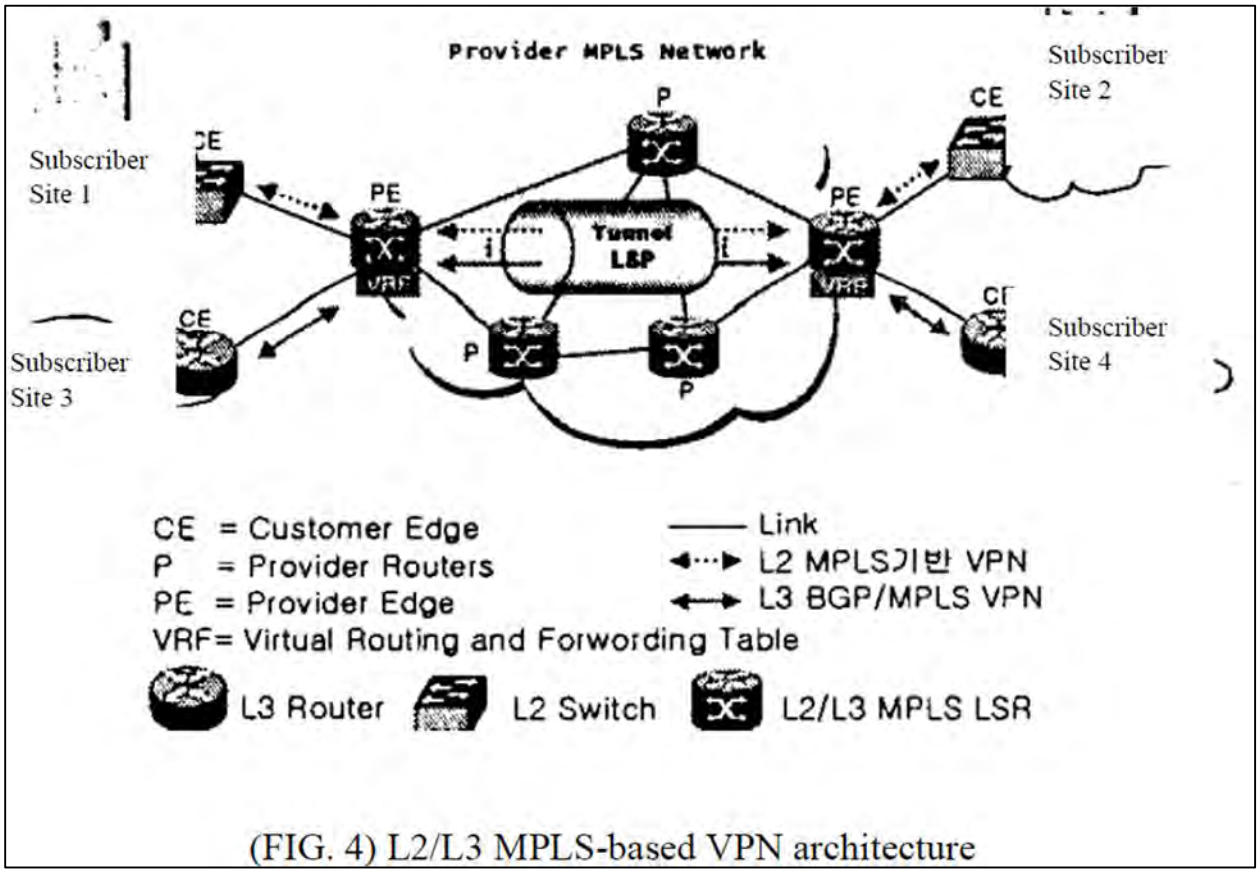
components of an MPLS-based VPN system that can be implemented over a PON (including CE and PE devices) as illustrated in Ahn's FIG. 2, reproduced below.



(FIG. 4) L2/L3 MPLS-based VPN architecture

218. Therefore, Ahn demonstrates that a POSITA would have understood that a PE device of a PON-based system (such as the PON-based system of G.984.1-3) is configured to accept a plurality of data streams, and the PE device is interconnected with a CE device that is serving a plurality of user devices through a plurality of ONUs based on the disclosure of RFC 4364 and Ahn. As discussed above, a POSITA would have viewed Ahn's discussion of using EPON as a suggestion to use the most prevalent form of a PON. At the time of the '142 patent's priority date, the most prevalent form of a PON was a GPON (as discussed in

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G.984.1-3), and a POSITA would have understood that implementation of VRF-based VPNs would have been performed in the same way on an EPON or GPON, and therefore a POSITA would have had a reasonable expectation of success in combining Ahn, G.984.1, G.984.3, RFC 4364.

3. [1.B] configuring said primary PON interface router to virtually separate the information intended for at least one private user device of a plurality of user devices, wherein said at least one private user device of a plurality of user devices is connected to at least one of said plurality of ONUs;

219. RFC 4364 and Ahn teaches [1.B].

220. The '142 patent explains that the PON interface routers "can be configured with Virtual Routing and Forwarding (VRF)" and "Virtual Local Area Network (VLAN) tagging" to "separate and manage the distribution of voice, video and data content traffic to each of the users." Ex. 1001, 4:52-56. This allows "data traffic intended for one tenant is automatically isolated from traffic intended for other tenants." *Id*., 5:50-52.

221. RFC 4364 explains how an MPLS-based VPN (as described in Ahn) virtually separates information intended for at least one private user device of a plurality of user devices by configuring a PE using a VRF. Ex. 1014, 8. The PE is configured with a separate VRF for each PE—CE attachment circuit, and the VRF includes destination address information that is looked up when the PE receives information destined for user device connected to a CE for which the information is

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directed. *Id*. As such, RFC 4364 teaches that a primary PON interface router can be configured to virtually separate the information intended for at least one private user device of a plurality of user devices. While RFC 4364 does not explicitly discuss a PON, the above discussion of limitation [1.A] demonstrates that RFC 4364's discussion of an IP backbone would have been relevant to G.984.1's discussion of a GPON, which is intended to standardized connections between users (using ONUs) and a network, such as using the PEs (a "PON interface router" as recited in claim 1) discussed in RFC 4364. Therefore, in light of the above discussion of why a POSITA would have been motivated to combine Ahn, G.984.1, G.984.3, and RFC 4364, these references teach limitation [1.B].

222. Ahn also describes MPLS and VRF usage for providing data streams over a network, specifically over a PON. Ahn explains that "routing and MPLS edge functionalities are implemented at the OLT level" – the same functions that Ahn explains are performed by "PE" devices in Ahn's discussion of L2/L3 MPLS-based VPN technology. Ex. 1015, 3. Ahn explains that in a PON, "[d]ownstream data is broadcast from the OLT to multiple ONUs using variable-length packets…. Each of the packets includes, in its preamble, a unique identifier of the ONU to be transmitted." *Id*., 2. The headers allow each ONU to identify which packets are addressed to it, so that packets addressed to other ONUs are discarded. *Id*.

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4. [1.C]/[1.D] wherein said configuring comprises: generating at least one independently unique virtual routing table by using Virtual Routing and Forwarding (VRF);

223. The '142 patent explains that the PON interface router "can be configured to run a routing table routing 412 that accesses the virtual routing table instantiations to create virtual routing tables 420, 422, 424, 426 for each Optical Network Unit (ONU) serving a tenant." Ex. 1001, 5:42-46. This is reflected in Figure 3, reproduced below. As explained by the '142 patent, this "supports the overlapping of IP addresses for any of the tenants because the routing instances are independent." *Id*., 5:46-50.

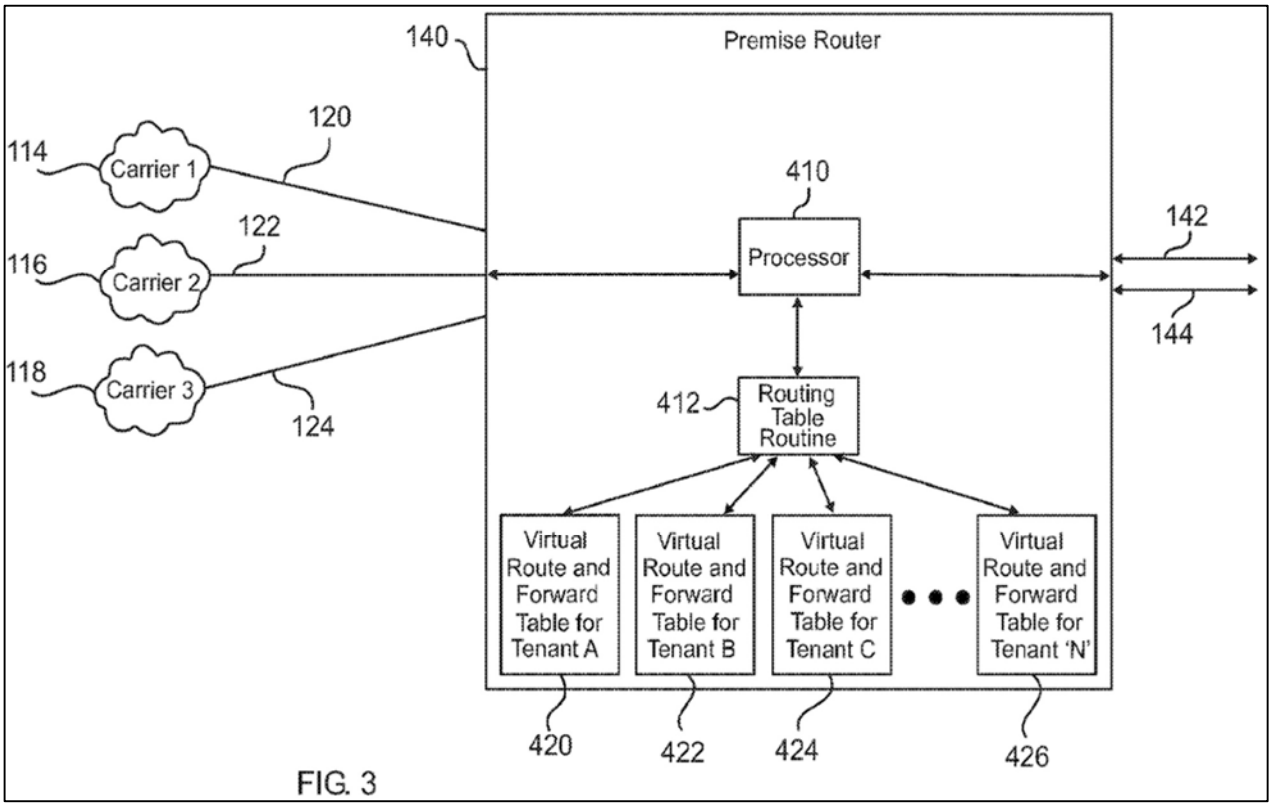

FIG. 3

224. The ’142 patent also provides pseudo-code for generating and implementing virtual routing tables for each of a plurality of ONUs. I have added line numbers that correspond with the lines in Column 6 of the ’142 patent for convenience:

[11] !---Begin gateway configuration and programming
[12] !---Configure gateway identity
[13] !---Establish express forwarding to optimize network per-
[14] formance and scalability
[15] !---For each tenant (1 . . . n) Do
[16] !---Instantiate virtual route table for the Tenant
[17] !---Enable VPN (Virtual Private Network) for the Tenant
[18] !---Establish routing and forwarding for the virtual rout-
[19] ing table
[20] !---Creates lists of import and export route-target
[21] extended communities
[22] !---End Do
[23] !---Set IP (Internet Protocol) address, netmask and enable
[24] IS-IS routing
[25] !---For each tenant (1 . . . n) Do
[26] !---Establish loopback identifier for the Tenant
[27] !---Enable VRF (Virtual Routing and Forwarding) for the
[28] Tenant
[29] !---Associate the VRF instance with an interface or sub-
[30] interface.
[31] !---Loopbacks use the same IP address because they

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[32] belong to different Tenant VRF's

[33] !---Broadcast to all hosts on the subnet

[34] !---End Do

[35] !---Define and configure the gateway ingress interface

[36] !---Set bandwidth

[37] !---Config IP address and netmask

[38] !---Enable MPLS (MultiProtocol Label Switching)

[39] !---Enables logging of BGP (Border Gateway Protocol)

[40] neighbor resets.

[41] !---Adds an entry to the BGP or multiprotocol BGP

[42] neighbor table

[43] !---Enables BGP sessions to use a specific operational

[44] interface for TCP (Transmission Control Protocol) con-

[45] nections

[46] !---Enter address family configuration mode

[47] !---Sends the community attribute to a BGP neighbor

[48] !---For each tenant (1 . . . n) Do

[49] !---Set the address family for the tenant

[50] !---End Do

[51] !---Use longest prefix matching or default route

[52] !---end gateway configuration and programming

Id., 6:11-52.

225. Lines 15-19 of the above pseudo-code detail the creation of independently unique virtual routing tables using VRF tables.

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226. RFC 4364 teaches this limitation. RFC 4364's Section 3 explains that each PE has the same capability as the recited limitation [1.D]. Each PE "maintains a number of separate forwarding tables. One of the forwarding tables is the 'default forwarding table'. The others are 'VPN Routing and Forwarding tables', or 'VRFs'." Ex. 1014, 9. Each attachment circuit between PE/CEs is associated, "by configuration," with one or more VRFs. *Id*. Whenever a new attachment circuit between the PE and a new CE is started, a new VRF is generated so that the PE is configured for the one or more VRFs. *Id*. Each new VRF includes an independently unique VRF table.

227. Section 3 of RFC 4364 goes on to explain that a VRF on a Provider Edge (PE) router contains the routes available to a particular set of customer sites. *Id.* Additionally, Section 4, entitled "VPN Route Distribution via BGP," describes the mechanism that makes the routes within each VRF "unique" across the service provider's network, even if different customers use the same private IP address space. It explains how a Route Distinguisher (RD) is used to create globally unique VPN-IPv4 addresses, explaining "[i]f several VPNs use the same IPv4 address prefix, the PEs translate these into unique VPN-IPv4 address prefixes. This ensures that if the same address is used in several different VPNs, it is possible for BGP to carry several completely different routes to that address, one for each VPN." *Id*., 13.

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228. Therefore, a POSITA would have understood that RFC 4364 and Ahn disclose generating at least one independently unique virtual routing table by using VRF.

5. [1.E] virtually separating at least one private data stream intended for said at least one private user device from said plurality of data streams using said at least one independently unique virtual routing table to create at least one virtually separated private data stream containing Internet Protocol (IP) data packages;

229. RFC 4364 and Ahn disclose this limitation.

230. As explained above, the '142 patent explains that the PON interface routers "can be configured with Virtual Routing and Forwarding (VRF)" and "Virtual Local Area Network (VLAN) tagging" to "separate and manage the distribution of voice, video and data content traffic to each of the users." Ex. 1001, 4:52-56. This allows "data traffic intended for one tenant is automatically isolated from traffic intended for other tenants." *Id*., 5:50-52.

231. Section 5 of the RFC provides a detailed description of a process for virtually separating a private data stream and forwarding the same to the intended private user device. This section includes a step-by-step logic flow of how a PE router handles an IP packet received from a CE device for forwarding to another CE device associated with an intended recipient:

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232. First, a PE router receives an IP packet from a CE router. Ex. 1014, 23. The PE router then “chooses a particular VRF in which to look up the packet’s destination address.” *Id*. This is the first step in the claimed "virtual separation."

233. Next, the PE router looks up the packet’s destination IP address of the “at least one private user device” in the located VRF. Assuming a match is found, the PE learns the packet’s “next hop” (i.e., the CE router destined to receive the IP packet). *Id*., 23-24. Because the packet is sent over a VPN, the PE router does not perform a lookup in the main routing table or any other customer's VRF. The routing table used to lookup the CE router and IP address is the claimed "independently unique virtual routing table."

234. Based on the result of that VRF lookup, the PE router determines the next hop and, when the next hop requires passing the packet across the IP backbone, the PE router encapsulates the packet (e.g., using an MPLS label) for transport across the provider's network to the packet’s destination address. This encapsulation creates at least one virtually separated private data stream containing one or more IP data packages that is a "virtually separated private data stream" isolated from all other traffic. *Id*., 24.

235. This is also reflected in Ahn’s discussion of a “tunnel” across the IP backbone that is part of the VPN implementation, and so a POSITA would

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understand that the details described in RFC 4364 would have been used to implement the MPLS VPN discussed in Ahn. *See* Ex. 1015, 3.

6. [1.F] uniquely labelling said IP data packages contained in said at least one virtually separated private data stream using Multi-Protocol Label Switching (MPLS) to create MPLS labelled data packages;

236. The pseudo-code provided above from column 6 of the '142 patent recites enabling MPLS. Ex. 1001, 6:38-40.

237. RFC 4364 discloses [1.F]. As discussed in [1.E], above, RFC 4364 describes the creation of MPLS labelled data packages for transport across a network for virtual separation. Ex. 1014, 3 ("Each route within a VPN is assigned a Multiprotocol Label Switching (MPLS) [MPLS-ARCH, MPLS-BGP, MPLS-ENCAPS] label; when BGP distributes a VPN route, it also distributes an MPLS label for that route."). Specifically, RFC 4364 describes the use of a "label stack" including a VPN Route Label (inner label) and an IGP Label (outer label). The inner label identifies the specific route within the destination PE router's VRF. RFC 4364 teaches that "before a customer data packet travels across the Service Provider's backbone, it is encapsulated with the MPLS label that corresponds, in the customer's VPN, to the route that is the best match to the packet's destination address. This MPLS packet is further encapsulated (e.g., with another MPLS label or with an IP or Generic Routing Encapsulation (GRE) tunnel header [MPLS-in-IP-GRE]) so that

it gets tunneled across the backbone to the proper PE router. Ex. 1014, 24. Thus, the backbone core routers do not need to know the VPN routes.

238. The IGP label (which RFC 4364 names the "IGP Next Hop") is used to forward the packet across the service provider's core network from the ingress PE to the egress PE. This label is determined by the provider's internal routing protocol (such as Open Shortest Path First (OSPF)) and is swapped at each hop until a PE determines that the next hop is a CE. *Id*., 25, 28. By labeling the IP data packages using an MPLS label, the IP data packages are ensured to remain in at least one virtually separated private data stream that is separated from other data streams. Therefore, a POSITA would have understood that RFC 4364 discloses [1.F].

7. [1.G] sending said plurality of data streams, including said at least one virtually separated private data stream comprising said MPLS labelled data packages, to said secondary PON interface router;

239. Although the '142 patent does not explicitly discuss sending data streams to a secondary PON interface router, a POSITA would have understood that the action of sending said plurality of data streams, including said at least one virtually separated private data stream comprising said MPLS labelled data packages, to said secondary PON interface router is the culmination of the process described in Section 5, "Forwarding" of RFC 4364. Section 5 describes the fundamental data plane logic of what to do with a packet once it arrives at a PE.

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240. RFC 4364 discloses this limitation for sending MPLS labelled data packages across an IP backbone between network routers. As discussed in Section 5 of RFC 4364, a PE router receives an IP packet from a CE device. Ex. 1014, 23. The PE then identifies a relevant VRF table and looks-up a forwarding address for the IP packet in the VRF associated with the input interface. *Id*., 24. This lookup determines the next-hop router (the next P-router or the egress PE) and the MPLS VPN label to use. *Id*. The PE router then encapsulates the packet with the appropriate MPLS labels, as discussed above and as detailed in Section 7 of RFC 4364. *Id*., 27.

241. Finally, it sends (or "tunnels") the resulting MPLS packet with the included IP packet to the next-hop router (e.g., a second PE router, which embodies the secondary PON interface router) via the appropriate physical interface as a part of the virtually separated private data stream of the plurality of data streams. *Id.,* 24.

242. As discussed above, a POSITA would have understood that RFC 4364's discussion of tunneling MPLS-labeled data packages across an IP network would have been used with a PON, such as the GPON discussed in G.984.1 and G.984.3, so that the PEs discussed in RFC 4364 would have been embodied as "PON interface routers" as recited in the claims that interface between a PON (as disclosed in G.984.1-3) and a network such as the IP backbone discussed in RFC 4364.

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8. [1.H] receiving said plurality of data streams including said at least one virtually separated private data stream at said secondary PON interface router;

243. *See* limitation [5.A].

244. The ’142 patent describes the functionality of the secondary PON interface router (and the corresponding OLT) with respect to figure 4. The ’142 patent explains that Figure 4 (reproduced below) “represents the Passive Optical Network infrastructure which is an optical distribution network used to convey the photonic broadcast stream feeds that contain the encrypted data packets such as VLAN-tagged ethernet frames.” Ex. 1001, 6:58-62. Those data packets are part of telecommunications service traffic that includes Internet, public switched telephone networks, and broadcast/cable television, which is received at a “secondary” PON interface router that passes the data packets to the illustrated OLT. *Id*., 4:23-26.

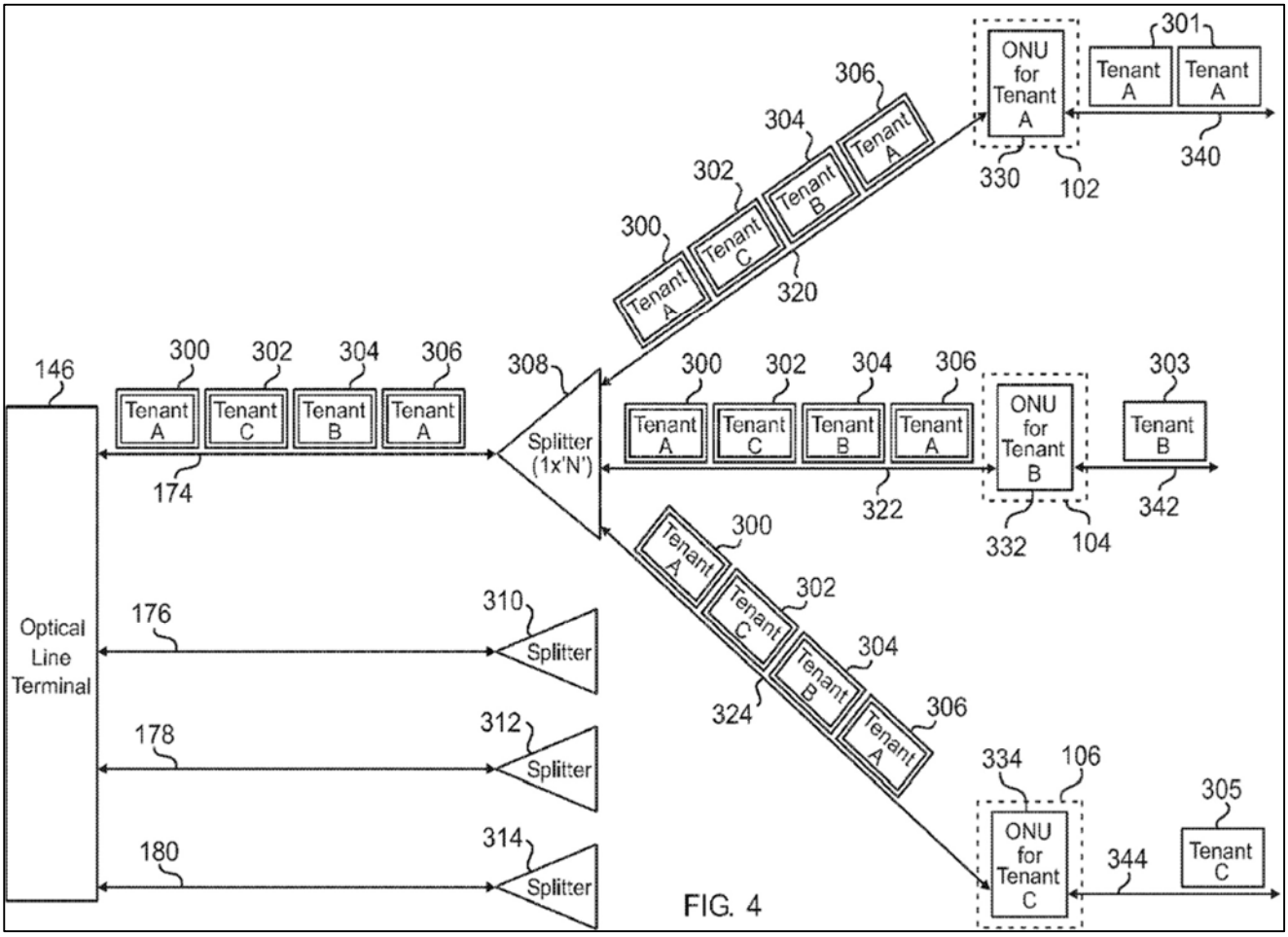

FIG. 4

245. RFC 4364 discloses this limitation for a network interface router (and as discussed above, a POSITA would have understood that RFC 4364's PEs could have been embodied as PON interface routers as discussed in G.984.1-3). As discussed above, RFC 4364 describes a first PE router forwards/tunnels an IP packet within a MPLS packet to "the next hop," such as a second PE router "where the VPN label will be examined." Ex. 1014, 25. The treatment of the packet at the second PE router depends on the VPN route label of the received packet in the at least one virtually separated private data stream of the received plurality of data streams. *Id*.

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The second PE "may only be able to determine that the packet's destination address needs to be looked up in a particular VRF before being forwarded to a CE device." *Id*. A POSITA would have understood that a second PE can only determine a packet's destination address once that second PE *receives* the IP packet.

9. [1.I] converting said MPLS labelled data packages contained within said at least one virtually separated private data stream back to said IP data packages;

246. The '142 patent does not discuss converting MPLS labelled data packages to an IP data package. The '142 patent explains that uniquely VLAN-tagging data streams allows "overlapping IP address[es] on a single PON infrastructure" (Ex. 1001, 5:65-67), so that IP data packages can be delivered to their intended destination.

247. RFC 4364 discloses this limitation. Section 5 of RFC 4364 explains how a PE (e.g., the second PE) forwards information to a recipient CE. Ex. 1014, 25. Once the MPLS labelled data package arrives at the second PE, the PE "determines the attachment circuit over which the packet should be transmitted (to a CE device), as well as the proper data link layer header for that interface." *Id*.

248. As RFC 4364 explains, "if the packet was an unlabeled IP packet when it arrived at its ingress PE, it will again be an unlabeled packet when it leaves its egress PE." *Id*., 25. To recreate the "unlabeled" IP data package, the PE "pops" the label stack (i.e., removes the MPLS label) of the MPLS labelled data packages

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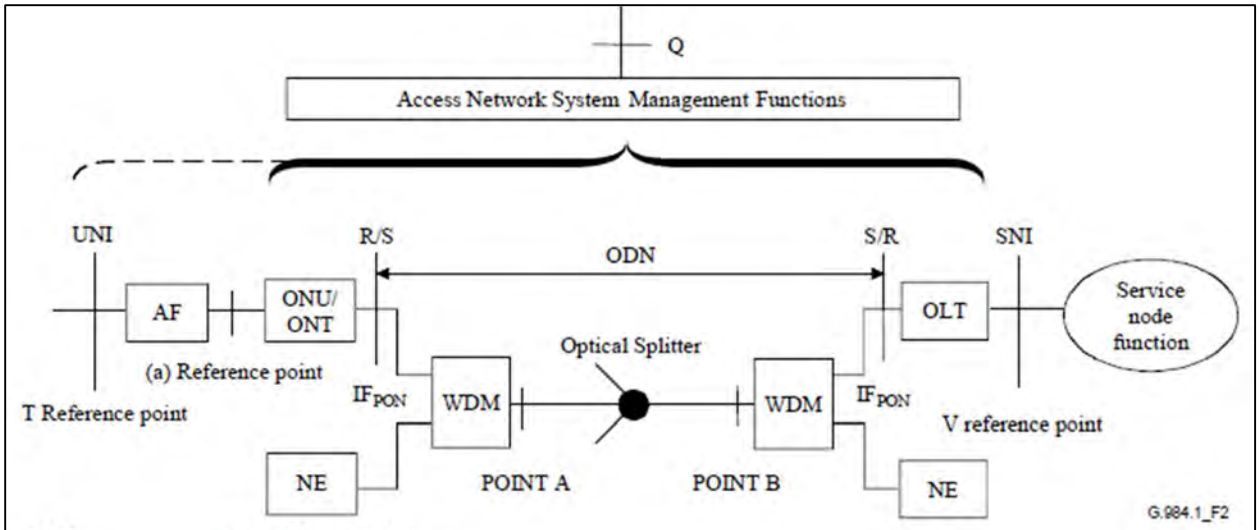
contained within said at least one virtually separated private data stream and sends the contained IP data package to its destination CE, as determined within the VRF table identified using the MPLS label of the data package. *Id*., 17, 25.

10. [1.J] forwarding said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages from said secondary PON interface router to a PON optical line terminal (OLT);

249. As discussed above, the ’142 patent explains that data streams are provided from the PON interface router to the OLT to forward broadcast stream feeds to various tenant spaces. Ex. 1001, 6:58-64.

250. G.984.1 and Ahn each disclose this limitation.

251. As shown in Figure 2 from G.984.1, for example, data streams are forwarded from the service node function to an OLT before the data streams are provided to the end users (e.g., at an ONU). Ex. 1011, 12.

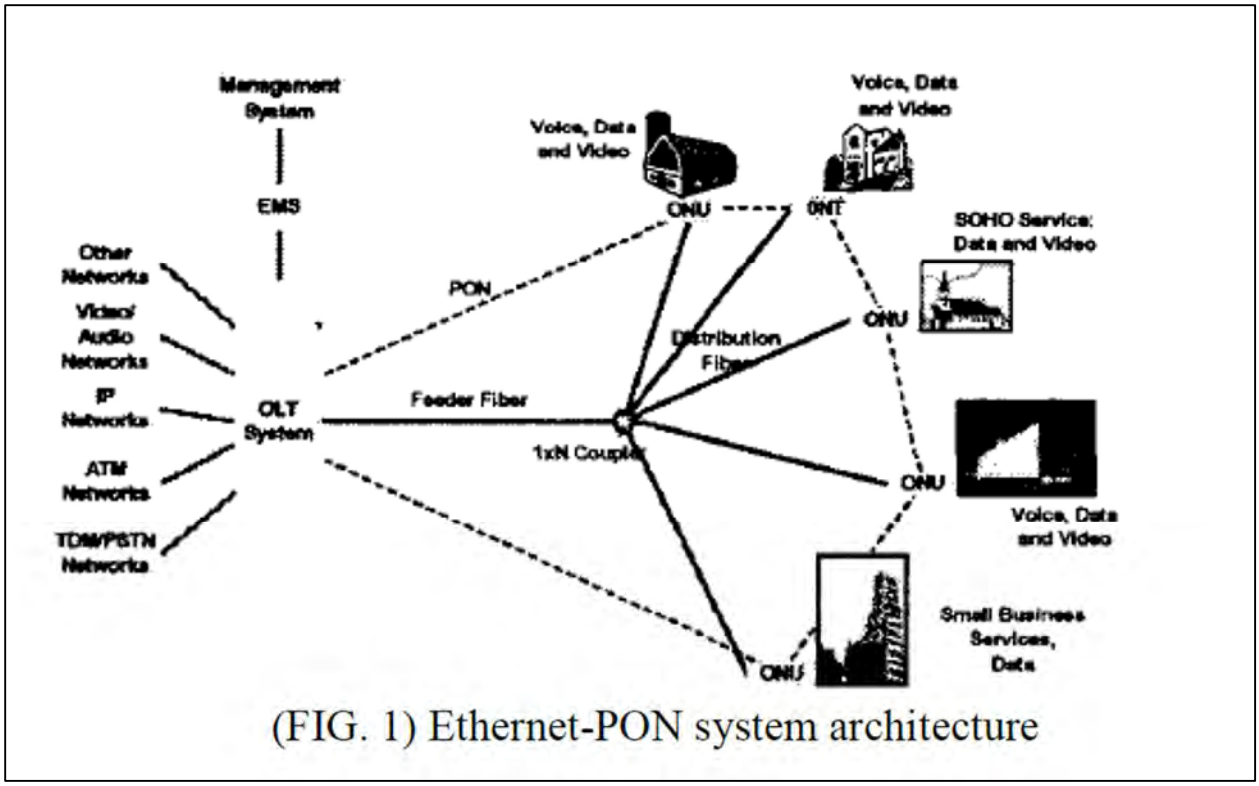


ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

252. Ahn explains the same configuration, specifically for providing VRF-based VPNs over a PON. Ahn explains that an OLT is located at a Central Office, and is connected to a network, such as an "IP backbone." Ex. 1015, 2. The OLT is also connected to a plurality ONUs at customer locations, as shown in FIG. 1, reproduced below. *Id*.



(FIG. 1) Ethernet-PON system architecture

253. Because the OLT is connected to the IP backbone and the plurality of customer locations (the ONUs), the OLT is connected to a provider edge (PE) of the IP backbone network as discussed in Ahn (and in RFC 4364), so that the PE (e.g., the secondary PE of RFC 4364) forwards the plurality of data streams that are destined for ONUs connected with the OLT, including the at least one virtually separated private data stream containing said IP data packages. Ex. 1015, 2.

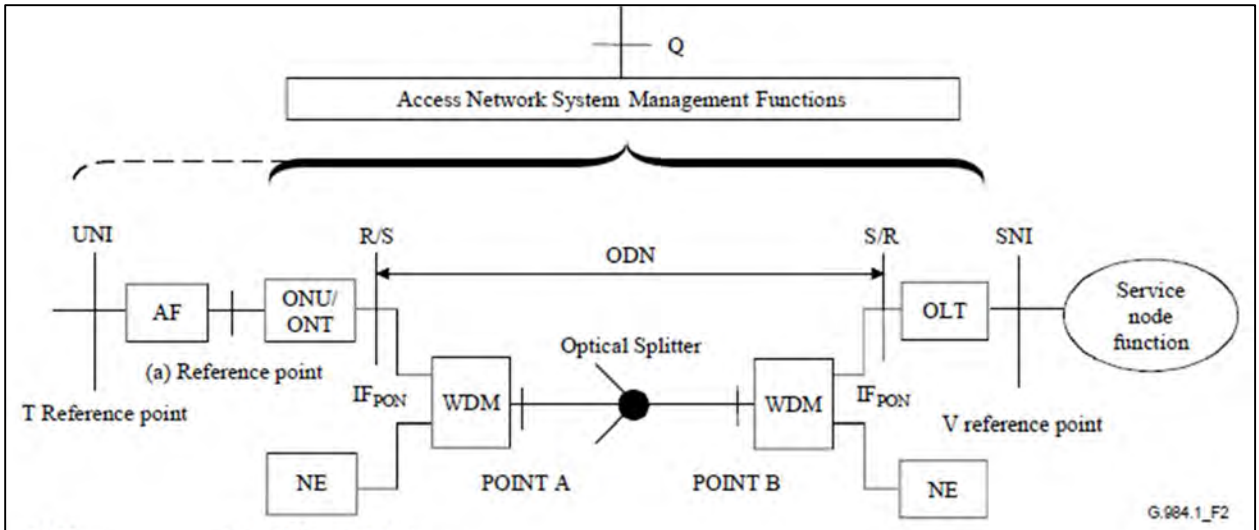
11. [1.K] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;

254. *See* limitation [5.B].

255. As shown in Figure 4 of the '142 patent (shown above), data streams for multiple tenants (specifically, Tenant A, Tenant B, and Tenant C) are all included

in a common data feed. Ex. 1001, 6:58-67. As the '142 patent explains "the OLT can broadcast the combined encrypted VLAN-tagged ethernet frames 300, 302, 304, 306 over the distribution feeds 174, 176, 178, 180 to a number of splitters 308, 310, 312, 314." *Id*.

256. G.984.1 and G.984.3 disclose this functionality of PONs. As shown in Figure 2 of G.984.1, shown below, signals are distributed to multiple end users using an optical splitter – a device that does not have any inherent ability to distinguish between different signals to different end users based on their intended end users. Instead, signals for any end user are included in the same, aggregated signal, and the signal is split using the optical splitter so that all end users receive all data signals in a single data feed. *See* Ex. 1011, 12.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

257. G.984.3 provides more detail about how data for different ONUs can be aggregated onto a common data feed, using time division multiplexing and GEM Frame-IDs that each receiving ONU uses to determine which data frames are relevant for the receiving ONU. Ex. 1013, 17.

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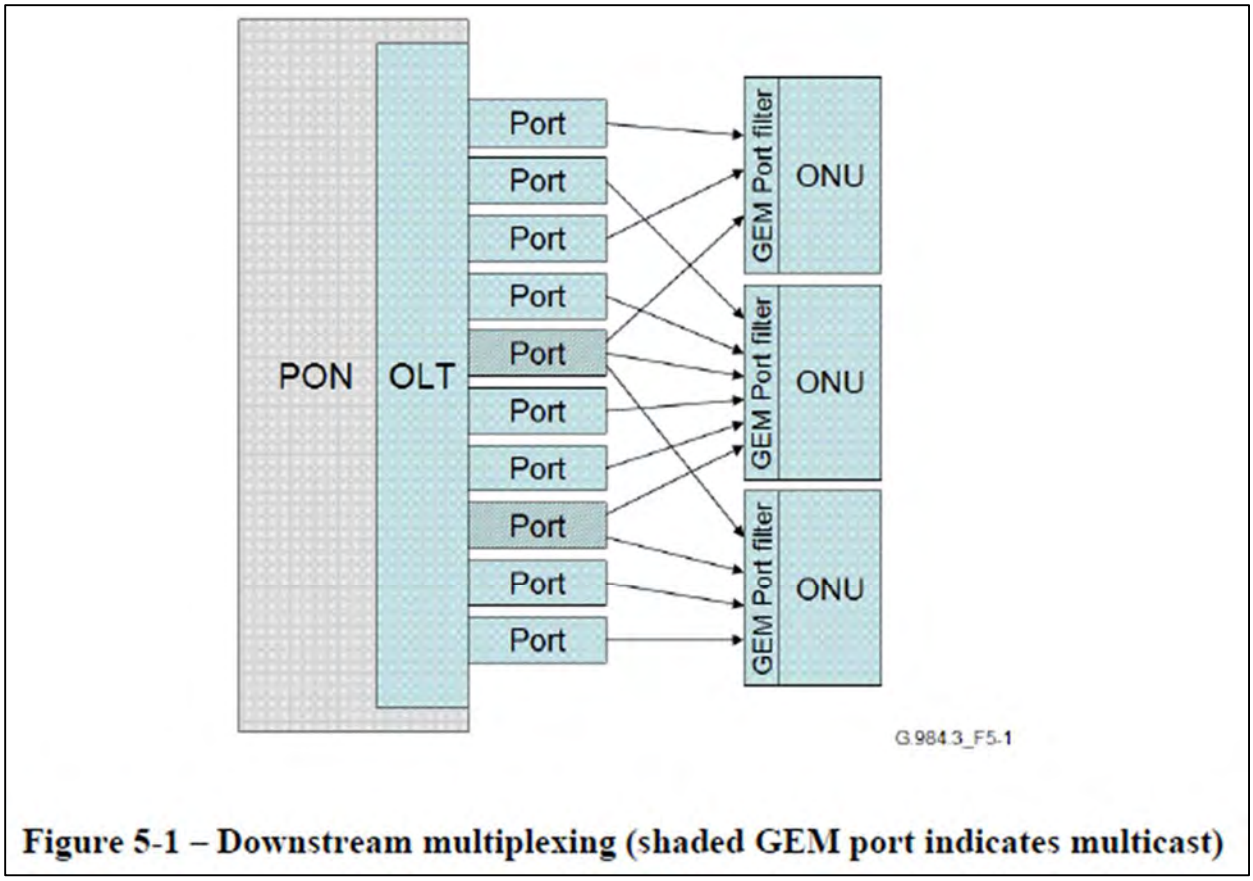

Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

Ex. 1013, 18.

258. Ahn also discloses "aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed."[7] Ahn explains that the OLT of a PON transmits a single data

[7] While there are some differences between how GPON (as discussed in G.984.1-3) and EPON (as discussed in Ahn) distribute data frames containing data to end users, the concept of aggregating data streams is a common feature to both – both standards are point-to-multipoint designs. *See* Ex. 1022.

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feed to the plurality of connected ONUs that is split by an optical splitter. Ex. 1015, 2 ("Downstream data is broadcast from the OLT to multiple ONUs using variable-length packets, that are a maximum of 1,518 bytes, in accordance with the IEEE 802.3 protocol."). The downstream data is aggregated in the OLT and then sent across the optical distribution network to the ONUs. This is shown in at least Figs. 1, 2, and 5. For example, a data feed is split into 3 separate lines each leading to a different ONUs, as shown in FIG. 2, reproduced below. The data feed includes signals aggregated by the OLT for each of the three ONUs. *Id*. When implemented with a VPN as discussed in Ahn, each of the signals are virtually separated and represent private data streams for the respective ONUs. *Id*. Each ONU only processes the packets addressed to it, and discards all others intended for different ONUs, thereby preserving the privacy of the data packets while they are in the aggregated data stream. *Id*.

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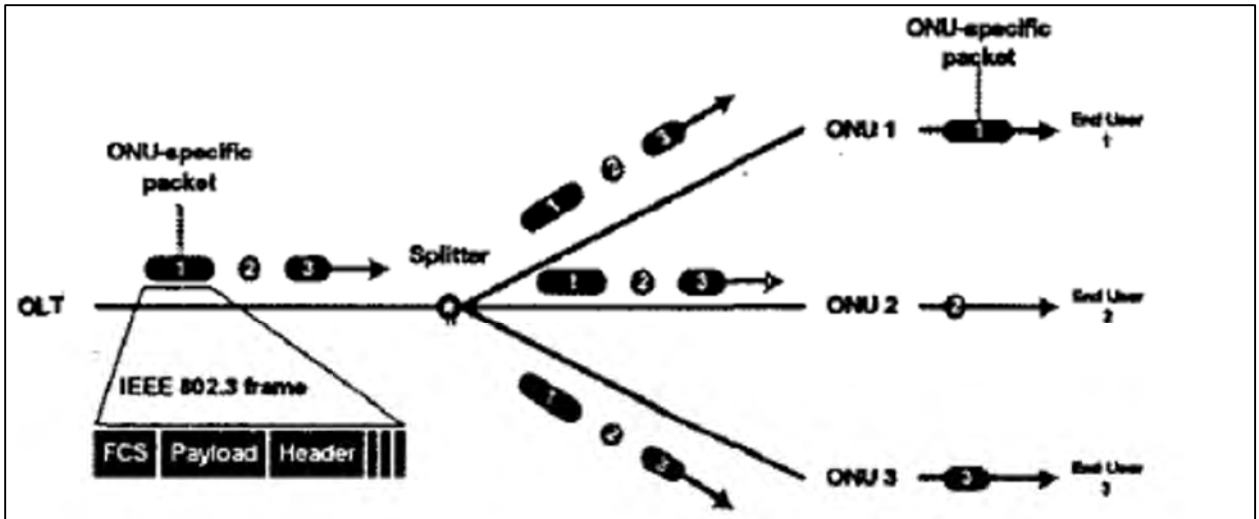
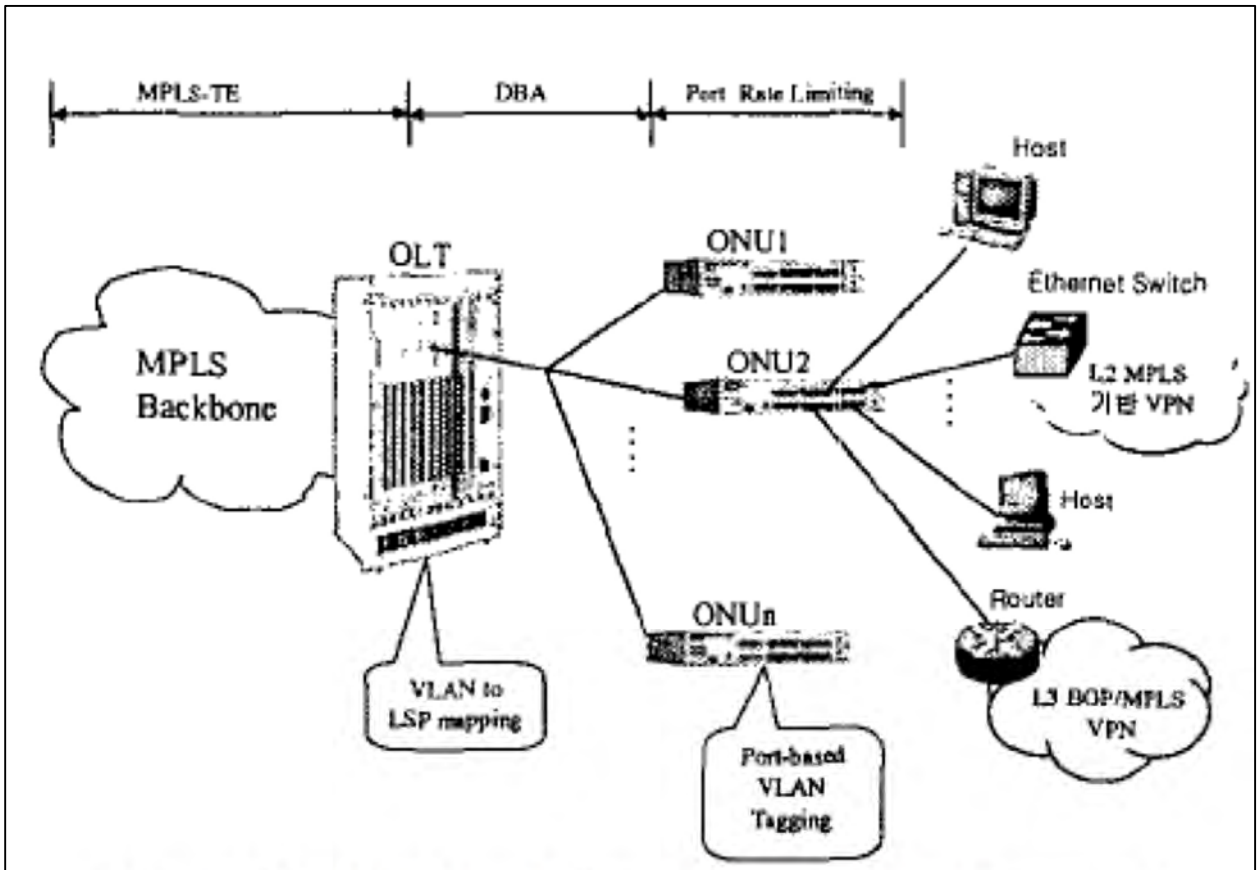


(FIG. 2) Flow of downstream traffic in EPON



(FIG. 5) L2/L3 MPLS-based VPN subscriber accommodation model

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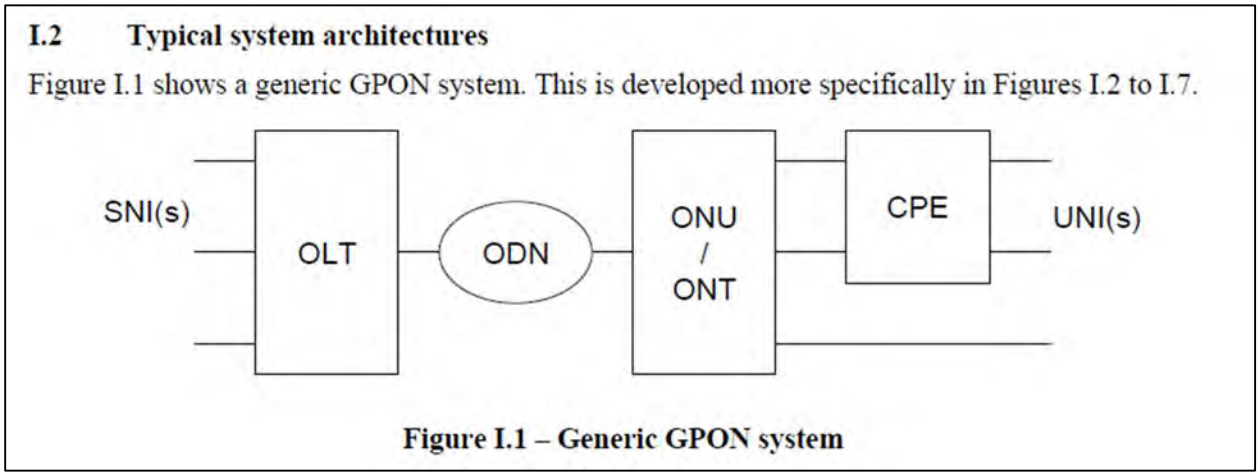
12. [1.L] distributing said common data feed to said plurality of ONUs;

259. *See* limitation [5.C].

260. As discussed above, both G.984.1 and Ahn disclose that the common data feed is distributed to a plurality of ONUs using the optical splitter that directs identical optical signals along optical lines connected with each of the ONUs. Ex. 1015, 2; Ex. 1011, 12.

261. For example. G.984.1 states that there are a plurality of ONUs that receive a common data feed from the OLT. Ex. 1011, 12. GPON systems are characterized, in general, by an optical line termination (OLT) system and an optical network unit (ONU) or optical network termination (ONT) with a passive optical distribution network (ODN) interconnecting them. There is, in general, a one-to-many relationship between the OLT and the ONUs.

262. This general architecture is depicted throughout G.984.1.



Ex. 1011, 20.

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263. G.984.3 discloses a one-to-many configuration for connecting an OLT to a plurality of ONUs at least in Fig. 5-1.

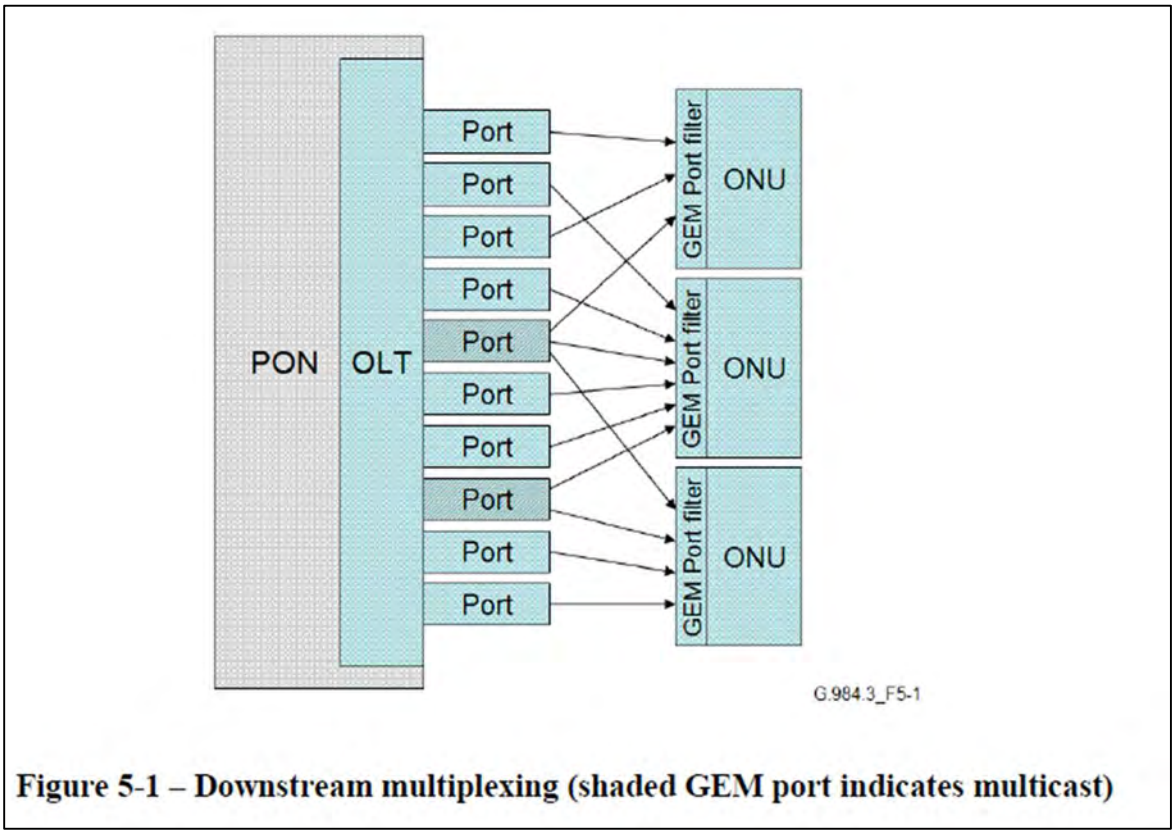
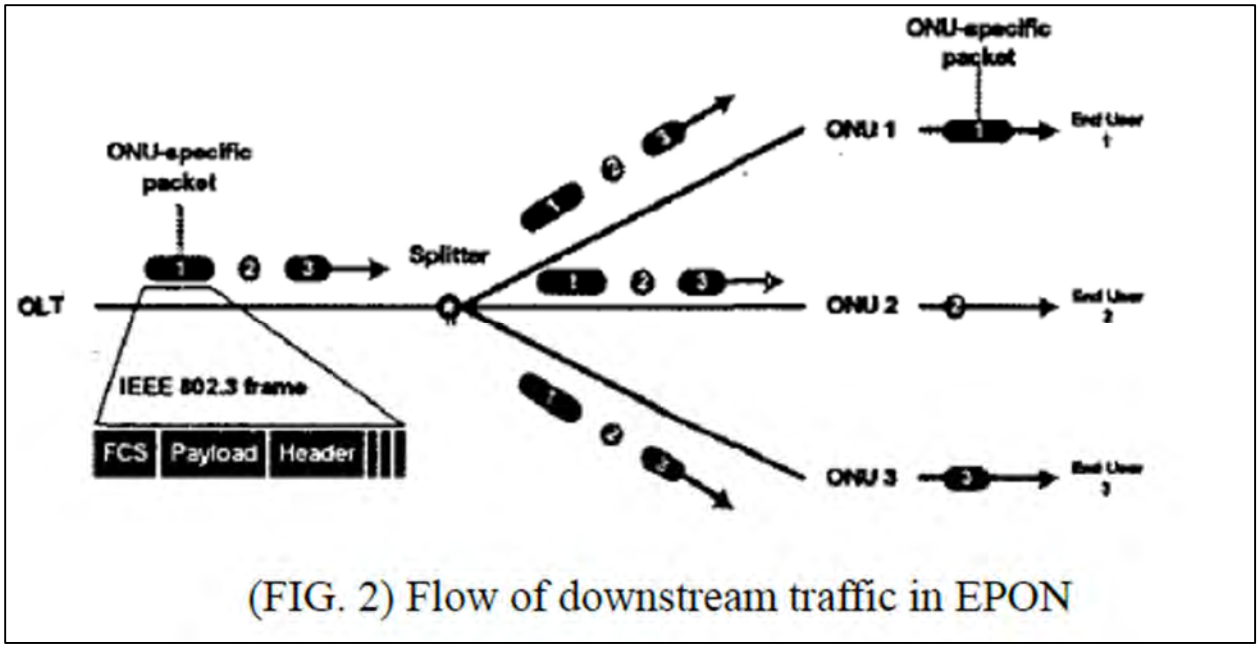


Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

Ex. 1013, 9.

264. As described above, Ahn also discloses and depicts distributing a common data feed to a plurality of ONUs, as shown at least in Figure 2.



(FIG. 2) Flow of downstream traffic in EPON

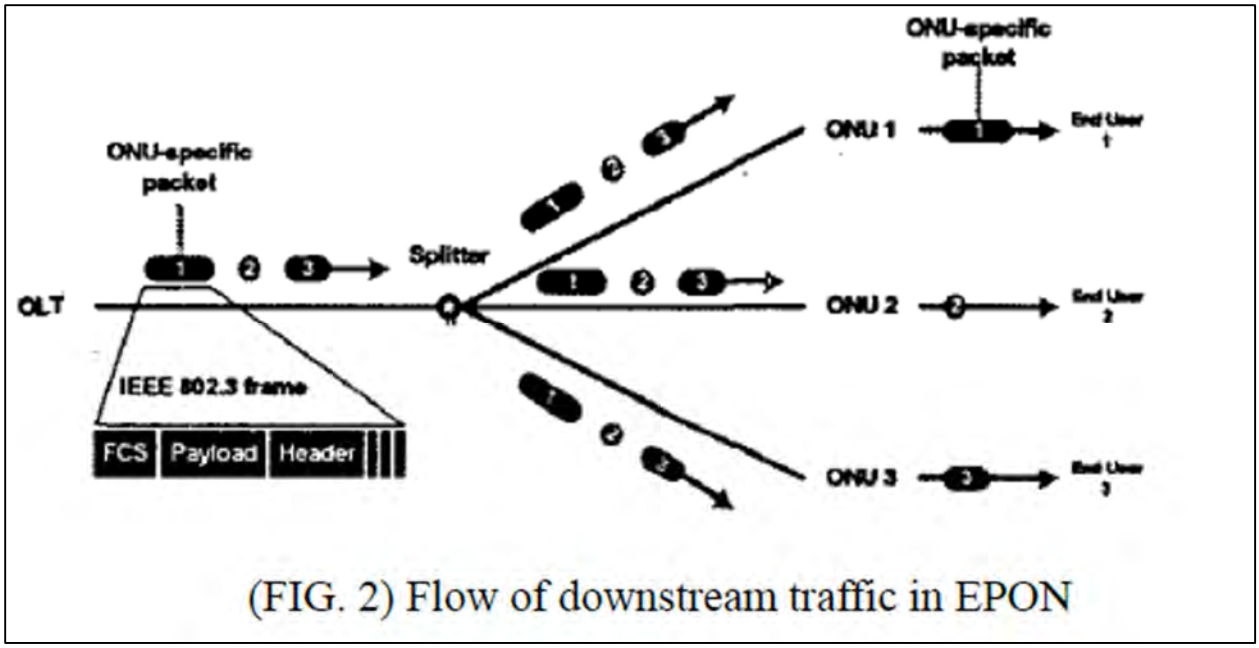
Ex. 1015, 2.

13. [1.M]/[1.N] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;

265. *See* limitations [5.D]/[5.E].

266. As discussed above, G.984.1, G.984.3 and Ahn discloses an optical splitter that replicates the common data feed and is connected to said plurality of ONUs. *Id*.

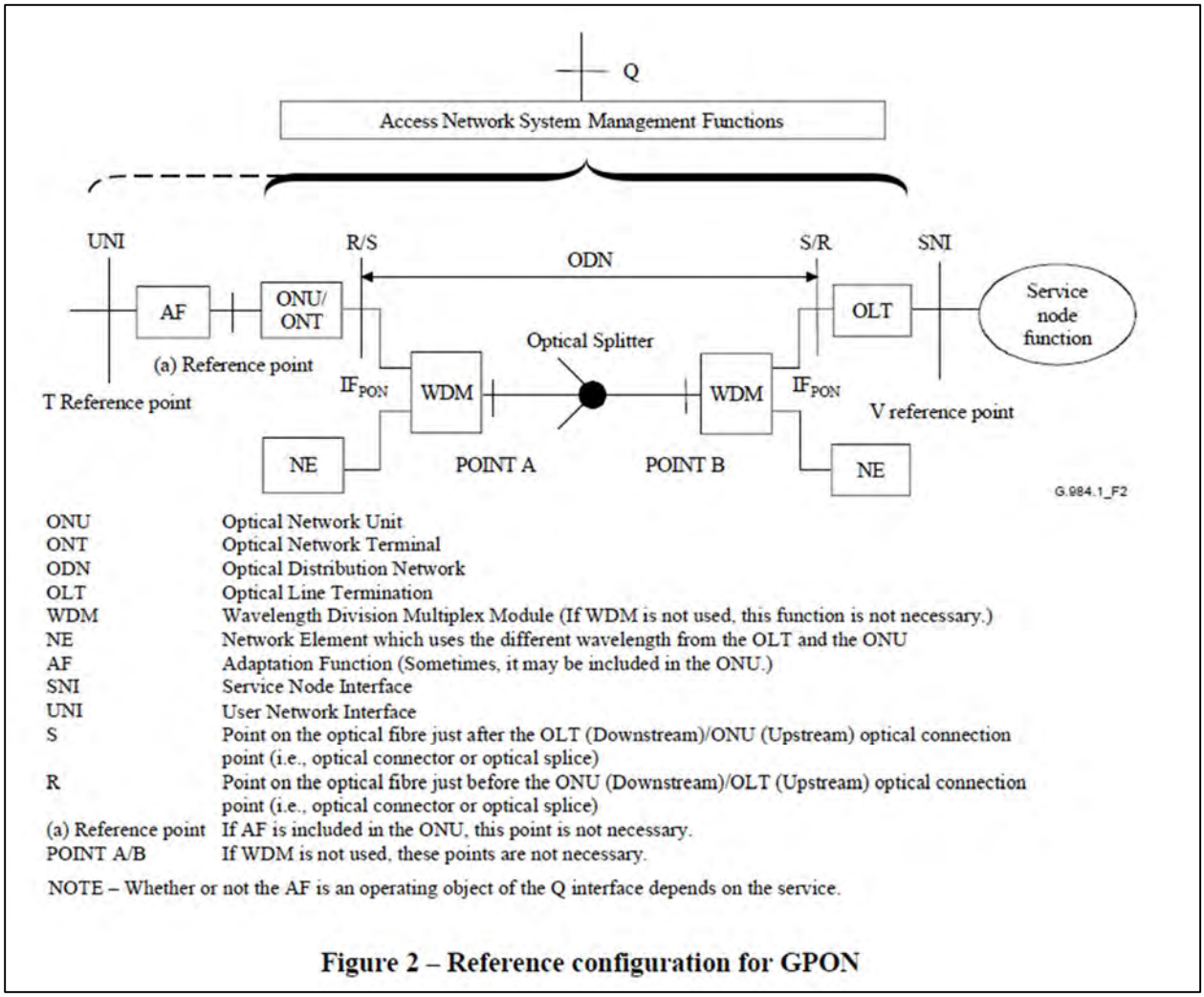
267. For example, Fig. 2 of Ahn explicitly depicts and labels the optical splitter for distributing a common data feed to a plurality of ONUs.



(FIG. 2) Flow of downstream traffic in EPON

268. Ahn further explains that "[t]he passive equipment of Ethernet-PON located in an ODN comprises single-mode optical fiber, passive optical fiber splitters/couplers, connectors, and the like." Ex. 1015, 2.

269. Similarly, Figure 2 of G.984.1 depicts the optical splitter.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
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POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

270. The splitter and the allowable split ratio is further discussed within G.984.1. *Id*. at 13. For example, it teaches that "split ratios of up to 1:64 are realistic for the physical layer, given current technology." *Id*. Here, the ratio is the number of ONU's (64) that can be connected with a single (1) OLT port. The "split" in "split ratio" refers to the use of optical splitters, that replicate the data feed to all of the ONUs connected with the splitter. *Id*. ("a larger split ratio implies greater optical splitting").

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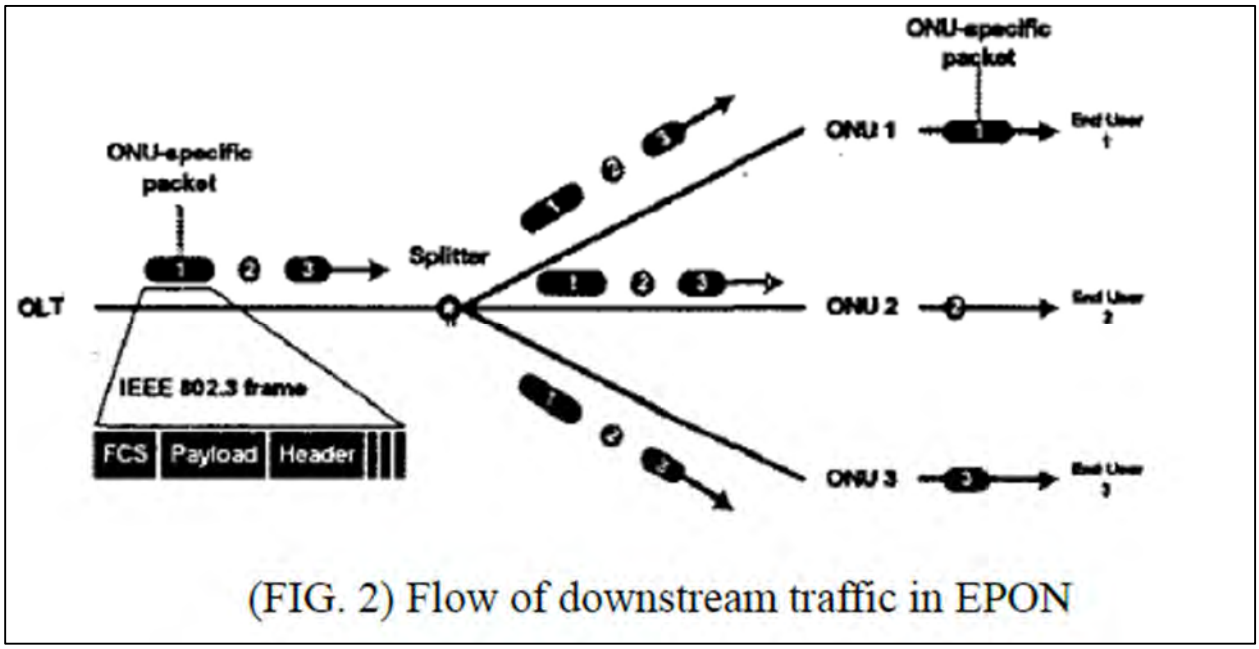
271. G.984.3 confirms the use of optical splitters to distribute signals from the OLT to a plurality of ONUs. Ex.1013, 22.

14. [1.O] delivering said common data feed to said plurality of ONUs;

272. *See* limitation [5.F].

273. As discussed above, the optical splitter of G.984.3 and Ahn's optical splitter is connected with optical lines connected each respective ONU, so that the common data feed is replicated and delivered to each of the plurality of ONUs. Ex. 1013, 14; Ex. 1015, 2.



(FIG. 2) Flow of downstream traffic in EPON

274. Ahn further explains that:

(FIG. 2) and (FIG. 3) show the downstream data transmission processing method from OLT to multiple ONUs, and the upstream data transmission method from multiple ONUs to OLT in an Ethernet-PON

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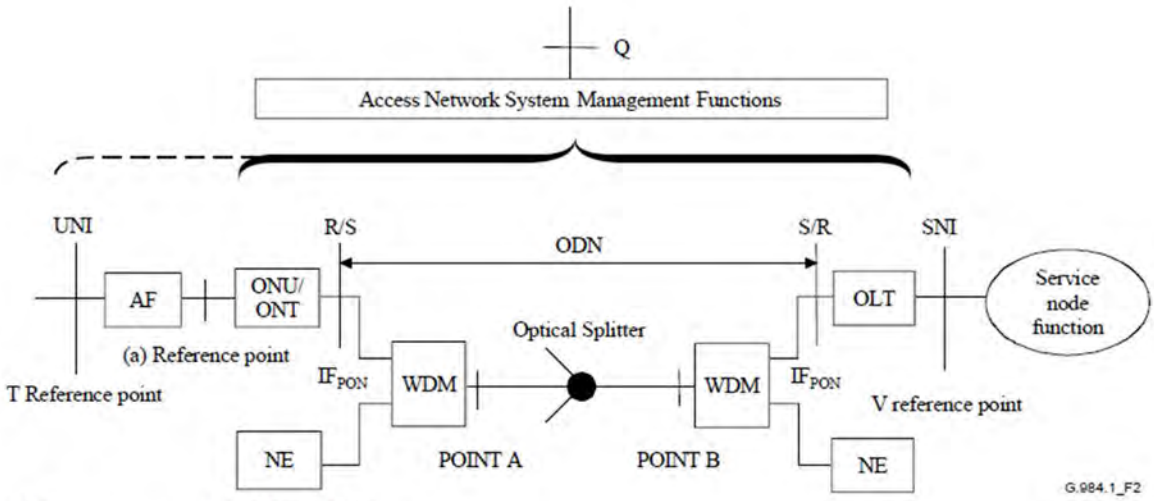
system. Downstream data is broadcast from the OLT to multiple ONUs using variable-length packets, that are a maximum of 1,518 bytes, in accordance with the IEEE 802.3 protocol.

Ex. 1015, 2.

275. Similarly, Figure 2 of G.984.1 depicts the optical distribution whereby the common data feed is delivered to the plurality of ONUs.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 13.

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276. As discussed, G.984.1 contemplates that at least 64 ONUs can be connected to a single OLT port. *Id*.

15. [1.P] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;

277. *See* limitation [5.G].

278. The '142 patent explains that "[e]ach ONU 330, 332, 334 is operated so that it utilizes the VLAN-tagging to select those of the incoming ethernet frames assigned to the particular tenant, and then removes the encryption from the selected ethernet frames." Ex. 1001, 7:22-25.

279. G.984.1 and G.984.3 discloses limitation [5.G]. GPON, as described in G.984.1 and G.984.3, utilizes the GPON Encapsulation Method (GEM), which is a data transport scheme to send data from the OLT to ONUs. Ex. 1013, 15-16. According to G.984.3 "GEM provides a connection-oriented, variable-length framing mechanism for transport of data services over the passive optical network (PON) and is independent of the type of the service node interface at the OLT as well as the types of UNI interfaces at the ONUs." *Id*. G.984.3 further explains that "IP packets are carried directed in the GEM frame payload." *Id.*, 128.

280. G.984.3 further explains that a given ONU only extracts the GEM frames that have been specifically addressed to that ONU despite the fact that the

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ONU receives the GEM frames for other ONUs that are part of the common data feed.

> In the downstream direction, the traffic multiplexing functionality is centralized. The OLT multiplexes the GEM frames onto the transmission medium using GEM Port-ID as a key to identify the GEM frames that belong to different downstream logical connections. Each ONU filters the downstream GEM frames based on their GEM Port-IDs and processes only the GEM frames that belong to that ONU.

Ex. 1013, 17.

281. As such, G.984.3 teaches that at least one of the ONUs extracts the virtually separated data stream that includes IP data packages from the common data feed that is received over the ODN.

282. As discussed above, once the common data feed is received at an ONU, Ahn discloses that said at least one of said plurality of ONUs extract said at least one virtually separated private data stream including said IP data packages from said common data feed. Ex. 1015, 2. Ahn explains that "each ONU processes only the packets addressed to it, discarding all others intended for different ONUs. For example, ONU1 receives Packets 1, 2, and 3; however only Packet 1 is delivered to User 1 [of FIG. 2]." *Id*. The "Packets" are the IP data packets received from the OLT, which were forwarded from the IP backbone network (from the first PE). *Id*. Ahn,

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therefore, also teaches that at least one of the ONUs extracts the virtually separated data stream that includes IP data packages from the common data feed that is received over the ODN.

16. [1.Q] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.

283. *See* limitation [5.H].

284. The '142 patent explains that once ONU-specific data feeds are decrypted, they are "then made available 340, 342, 344 for the tenant's IP/ethernet end-user equipment." Ex. 1001, 7:27-29.

285. As discussed above in [5.G], G.984.1 and G.984.3 discloses that a given ONU extracts only the IP packages from a GEM frame where the GEM port ID matches the ONU. The purpose of extracting that IP package is to send the IP package (in the at least one virtually separated private data stream) from the at least on ONU to the at least one private user device that is connected to that ONU of the plurality of user devices, while discarding any data that is intended for user devices connected to different ONUs. The purpose of an access network, such as the one described by G.984.1-3, is to provide access to user devices to a wider network, such as the internet or other IP networks. G.984.1 teaches a "User Network Interface" that exists downstream of an ONU, such as gigabit ethernet. Ex. 1011, 20. This is depicted in Fig. I.1.

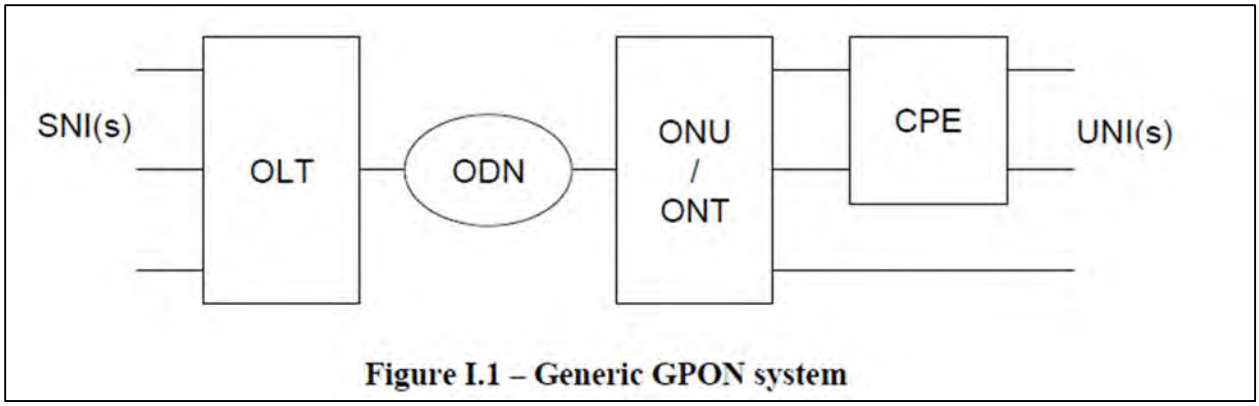

Figure I.1 – Generic GPON system

Id., 20.

286. G.984.1 further describes that "[i]n the ONT, Ethernet frames as defined in [b-IEEE 802.3] are extracted from the TC layer. In some ONTs, the Ethernet layer is quite abbreviated and little processing is done on the frames from their reception on the GPON interface to their transmission on the UNI." *Id*. G.984.1 further notes that "[i]n some ONTs, some sort of VLAN processing is done, as defined in the IEEE 802.1-series of standards." G.984.1 further explains that this can be to identify the specific user by a VLAN-ID.

> This typically involves adding tag(s) in the upstream, and removing tag(s) in the downstream, for the purpose of identifying each user/service packet via their VLAN-ID. However, this is not necessary in all cases, since the PON itself has the GEM port-ID mechanism for such identification.

Id.

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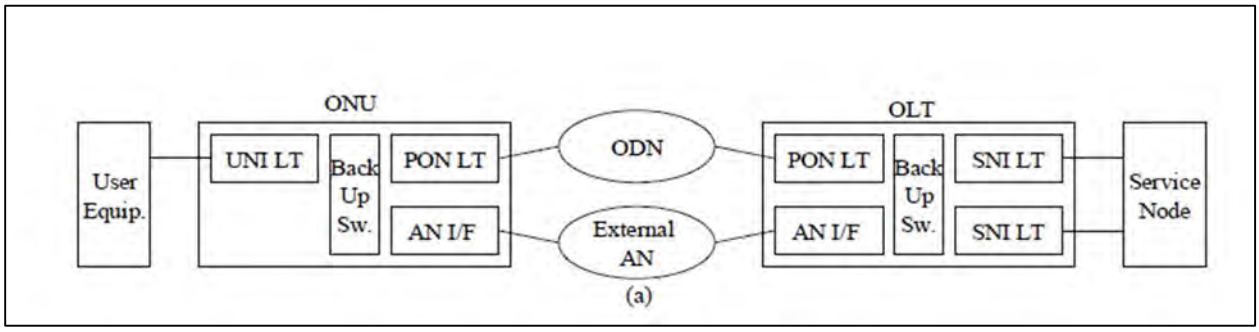
287. G.984.1 further confirms that user equipment is downstream of an ONU.



Ex. 1011, 34.

288. As discussed above, Ahn also discloses this limitation. Ahn explains that an ONU "receives" a plurality of data streams as a part of an aggregated common data feed, extracts only the data feed that is addressed to it, and then sends the extracted data packet (i.e., the at least one virtually separated private data stream including said IP data packages) to a private user device of an end user (User 1, in FIG. 2, above), which is one of a plurality of end users (and their corresponding devices), as shown in FIG. 2 of Ahn. Ex. 1015, 2.

I. Claim 2 – The method of claim 1, wherein said at least one of said plurality of ONUs provides services to at least one private user of plurality of users

289. *See* Claim 6.

J. Claim 3 – The method of claim 1, wherein said secondary PON interface router is serially connected to at least one additional PON interface router that is serially connected to said PON OLT, wherein said least one additional PON interface router delivers said plurality of data

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streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.

290. Although this limitation is not discussed in detail in the '142 patent, this is a typical configuration of data networks generally, as discussed in RFC 4364, and is a typical configuration of PON networks specifically, as disclosed in G.984.1 and G.984.3.

291. RFC 4364 discloses claim 3. RFC 4364 explains that "route reflectors" are used as interim routers between PEs to create a serial route of a plurality of routers to provide information from a first PE to an end user, through a series of routers, the OLT, and ultimately to an end user. Ex. 1014, 20, 23. RFC 4364 explains that "tunneling" between end points "DOES NOT require that the tunnels be point-to-point; multipoint-to-point can be used." *Id*., 26. Various "P routers" can be used as interim routers to determine a tunnel from edges. Therefore, the "secondary" PE router can be connected directly with the primary PE router, or there can be one or more interim routers that function to forward the at least one virtually separated private data stream containing said IP data package. In such a case, any of the interim routers can be a "secondary" router as the term is used in claim 3, which is serially connected to at least one additional router that is serially connected to said OLT (when the network is a PON). Therefore, RFC 4364 explains that the configuration of claim 3, with an "additional router" is usable in networks that provides VRF-based VPN services to end users. Ahn is consistent, and illustrates this connection

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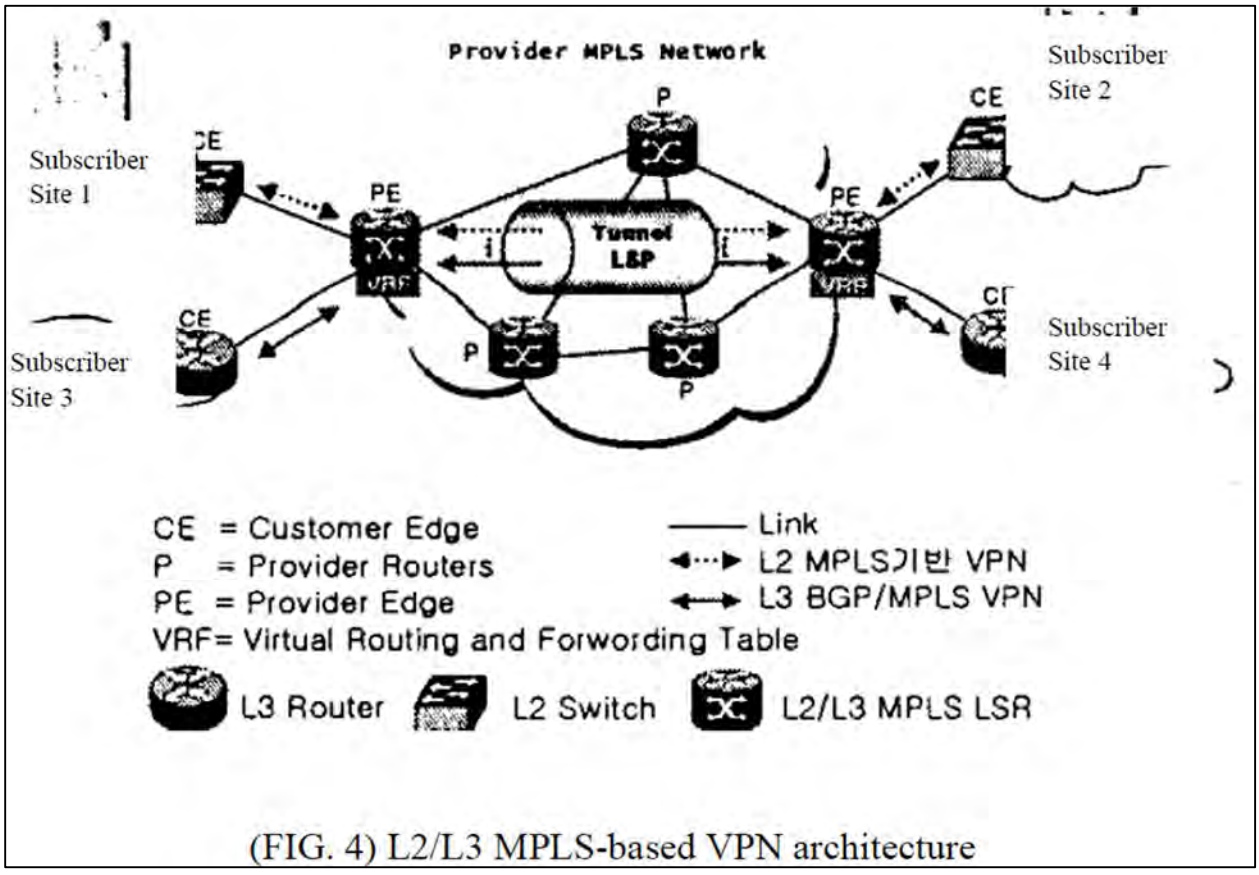
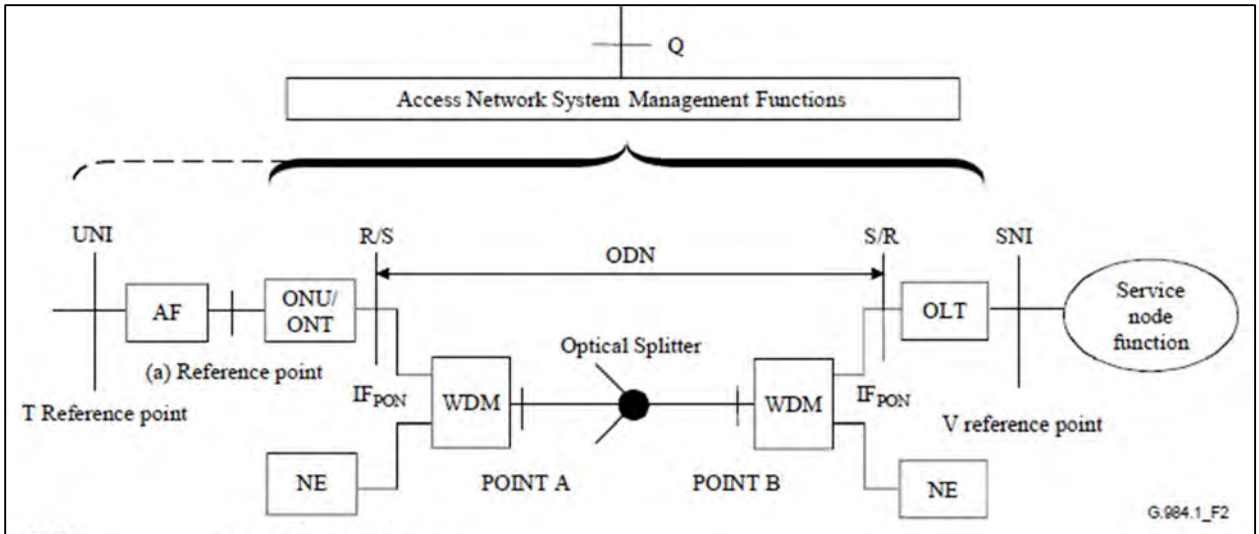
as a plurality of "P" routers connecting "PE" routers. Again, Ahn's disclosure provides that this network configuration (over an IP backbone) is usable with a network implementing VRF-based VPN services to end users.



(FIG. 4) L2/L3 MPLS-based VPN architecture

292. Lastly, G.984.1 confirms that this configuration is standard for PON networks. As shown in G.984.1's Figure 2, below, an OLT is connected to a service node function, such as a secondary PON interface router that forms a provider edge node of the PON. Ex. 1011, 12.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

K. Claim 4 – The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT

293. *See* Claim 7.

294. The ’142 patent states that “an aggregation switch [is] referred to as an Optical Line Terminal (OLT),” and is depicted in Fig. 2 as element “146.” Ex. 1001, 4:34-38.

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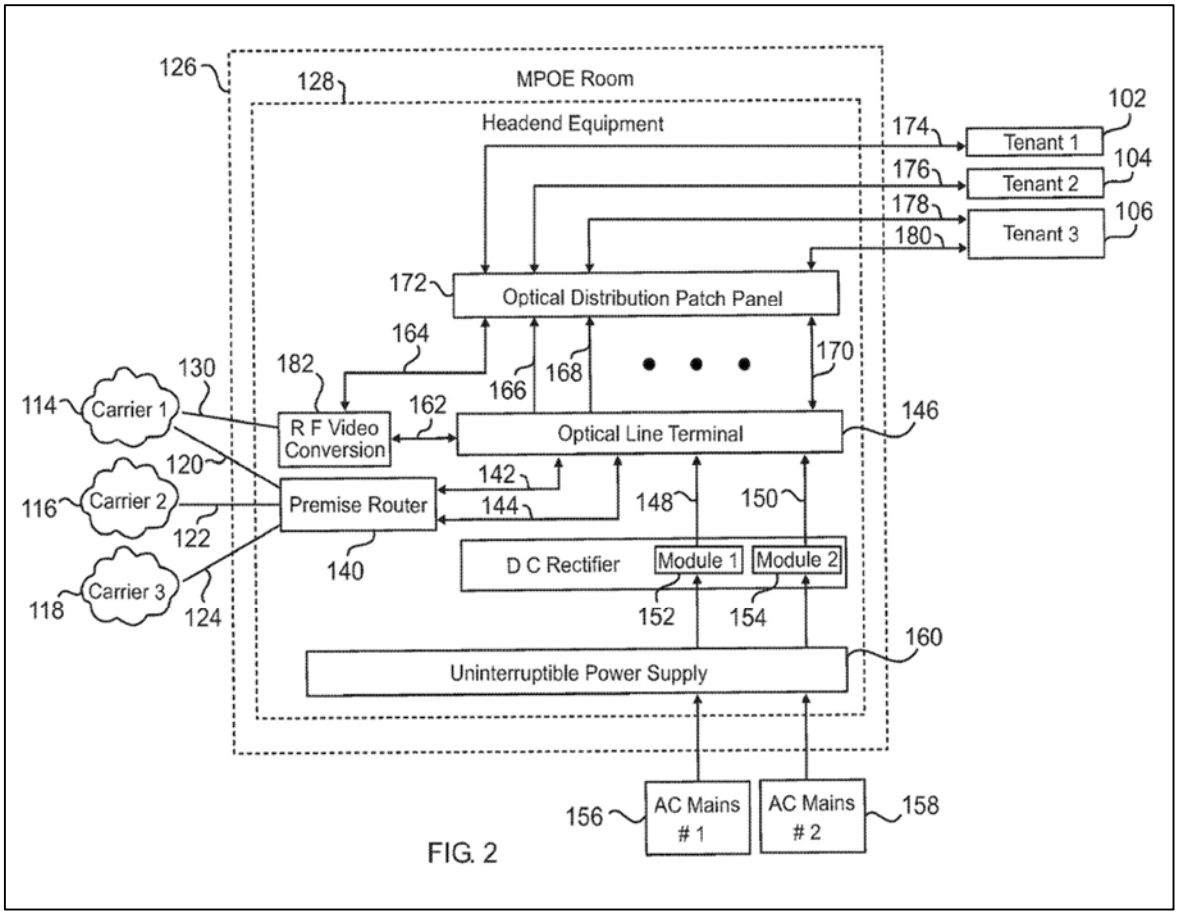

FIG. 2

295. G.984.1 discloses this claim, by explaining that an OLT includes an aggregation switch and a PON Line Terminal (PON LT) in serial connection with the aggregation switch. Ex. 1011, 14. G.984.1 discloses switches located between a service node interface and PON Line Termination (PON LT), to be connected in series with the PON Line Termination. *Id*. The switch delivers the plurality of data streams from the service node (which includes the virtually separate private data stream containing the IP data packages, received from the service node, as discussed above).

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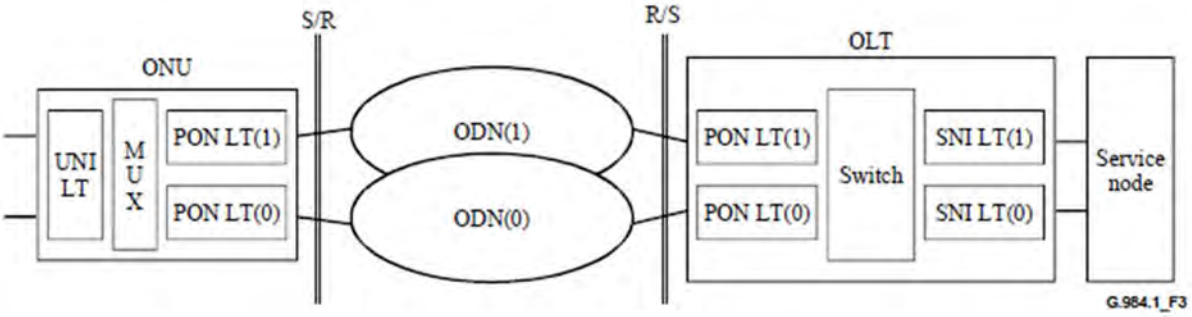
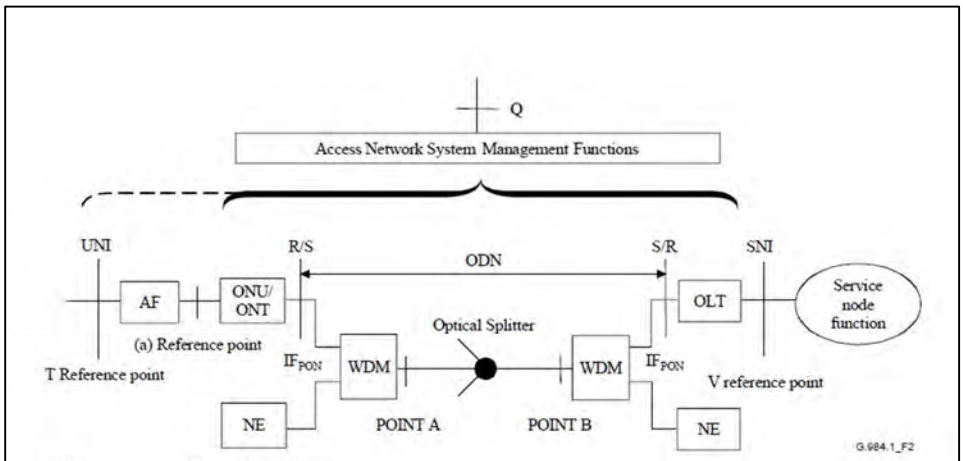


Figure 3a – Duplex system model

296. While Fig. 3a depicts the PON LT, the switch, and the SNI LT as part of the "OLT," a POSITA would understand that the PON LT is functioning as the OLT of Claim 7. This is further shown by Fig. 2 of G.984.1, which depicts the SNI as outside of the OLT. Ex. 1011, 12.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
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UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
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(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

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297. Regardless, the ’142 patent contemplates that the aggregation switch and the OLT could be contained within the same physical device. And Fig. 3a shows that a switch that is serially connected between the device that is performing the digital to optical conversion, the PON LT, and the broader network, which would include a PON interface router. *See* Claim [5.A].

XIII. Ground 2: The combination of Ahn in view of G.984.1, G.984.3 RFC 4364, and BCM56685 renders claims 4 and 7 obvious.

298. As discussed in Ground 1, claims 1-9 are obvious over the combination of Ahn, G.984.1, G.984.3, and RFC 4364. BCM56685 provides additional disclosure that is relevant to dependent claims 4 and 7, each of which recite an “aggregation switch” that “delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.” BCM56685 is a published product data sheet showing that such a product already existed, and was used when implementing a VRF over a PON. For at least those reasons discussed below, a POSITA would have been motivated to combine the teachings of BCM56685 with Ahn, G.984.1, G.984.3, and RFC 4364, and would have had a reasonable expectation of success in doing so. Therefore, claims 4 and 7 are obvious over the combination of Ahn, G.984.1, G.984.3, RFC 4364, and BCM56685.

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A. Motivation to Combine

299. As discussed in Ground 1, a POSITA would have been motivated to combine Ahn with G.984.1, G.984.3, and RFC 4364, and would have had a reasonable expectation of success. I believe that the combination discussed in Ground 1 is sufficient to show that all of claims 1-9 are obvious.

300. However, in addition to those reasons discussed in Ground 1 for combining Ahn with G.984.1, G.984.3, and RFC 4364, a POSITA would have been further motivated to look at BCM56685 when implementing an aggregation switch as a part of a VRF implementation over a PON, at least because BCM56685 demonstrates that such a product was already available prior to the ’142 patent filing date and marketed as providing functions for providing VRF services over a PON. BCM56685 is a published Broadcom datasheet that describes the features and benefits of an Ethernet switch chip that was available prior to the time of the ’142 patent filing date. The data sheet indicates that this chip supports “IPv4/v6 Routing with VRF and RPF.”

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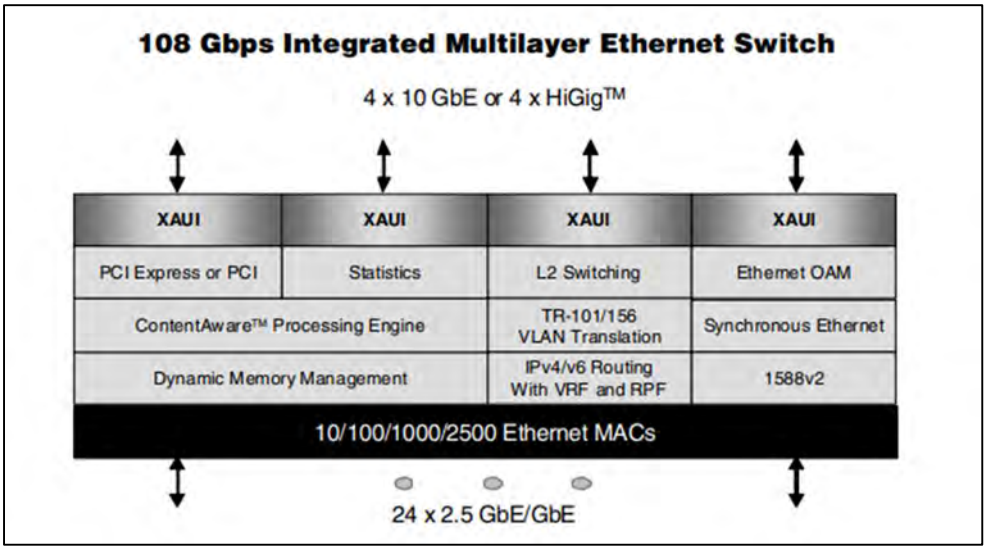
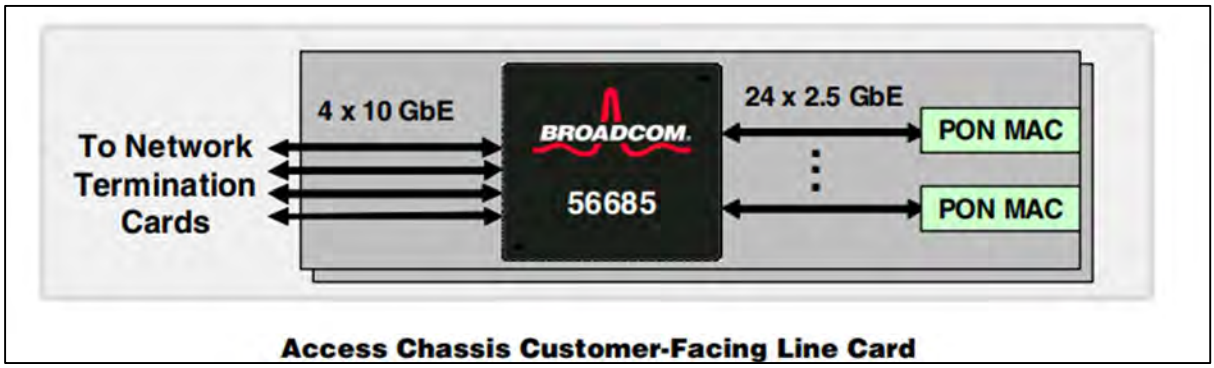


301. The datasheet also discloses that the described chip was intended to be deployed to facilitate the transport of data to and from a PON.



302. A POSITA reviewing this data sheet would have known that VRF separated traffic could be distributed on a PON to end users as this functionality was part of a publicly advertised and commercially available product from one of the largest semiconductor manufacturers and advertised in printed publications such as the above-mentioned BCM56685 datasheet for years prior to the priority date. A POSITA would have been motivated to look to both the prevalent PON standards of the time (GPON) for additional information regarding PONs and the relevant VRF

documentation (RFC 4364) for additional information regarding VRF, and to commercially available products, as discussed in BCM56685, for providing VRF functionality over a PON. A POSITA would have also had a reasonable expectation of success in implementing the teachings of BCM56685 with G.984.1, G.984.3, RFC 4364, and Ahn, at least because BCM56685 describes a commercially available product that is advertised as compatible with both PONs and VRFs such as those described in Ahn, G.984.1, G.984.3, and RFC 4364.

B. Claim 7 - The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream comprising said IP data packages to said PON OLT.

303. The ’142 patent states that “an aggregation switch [is] referred to as an Optical Line Terminal (OLT),” and is depicted in Fig. 2 as element “146.” Ex. 1001, 4:34-38.

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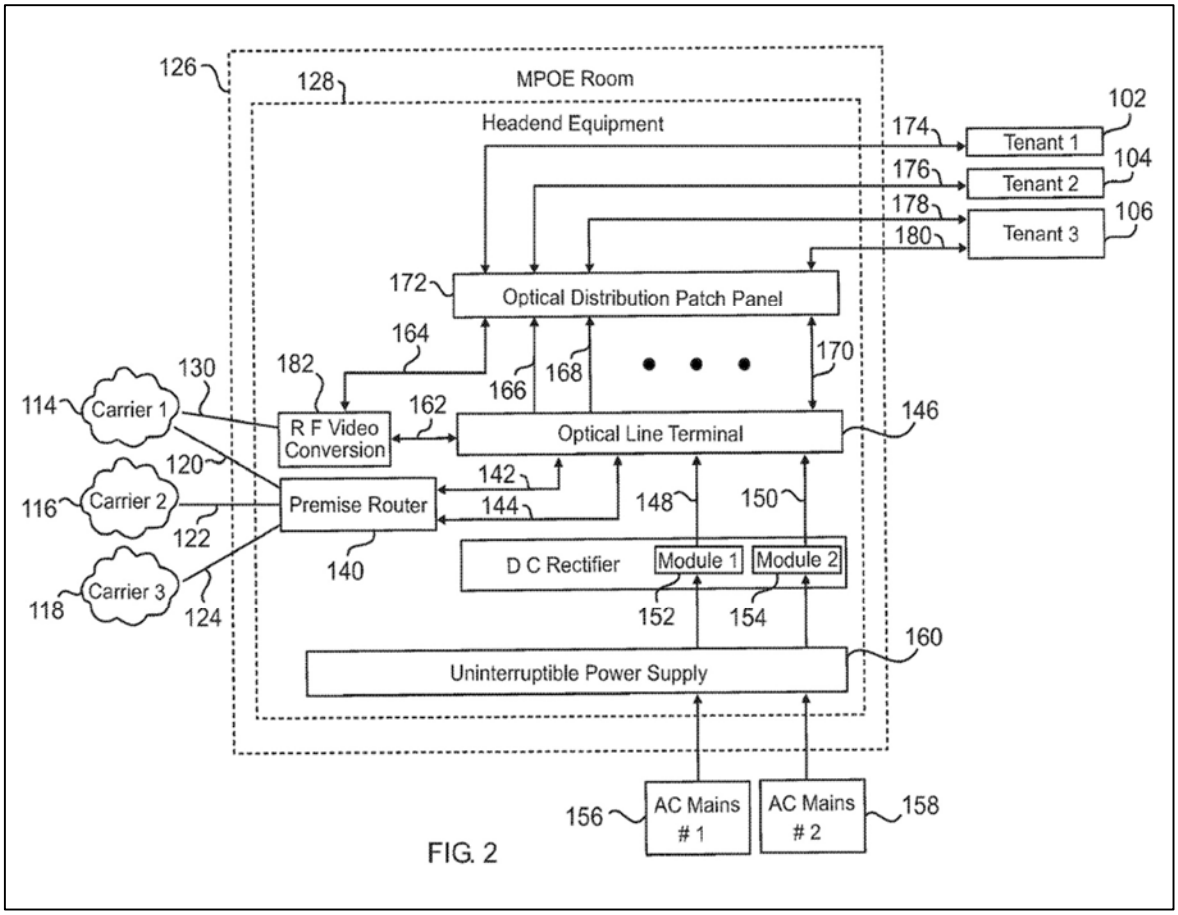


FIG. 2

304. G.984.1 discloses this claim, by explaining that an OLT includes an aggregation switch and a PON Line Terminal (PON LT) in serial connection with the aggregation switch. Ex. 1011, 14. G.984.1 discloses switches located between a service node interface and PON Line Termination (PON LT), to be connected in series with the PON Line Termination. *Id*. The switch delivers the plurality of data streams from the service node (which includes the virtually separate private data stream containing the IP data packages, received from the service node, as discussed above).

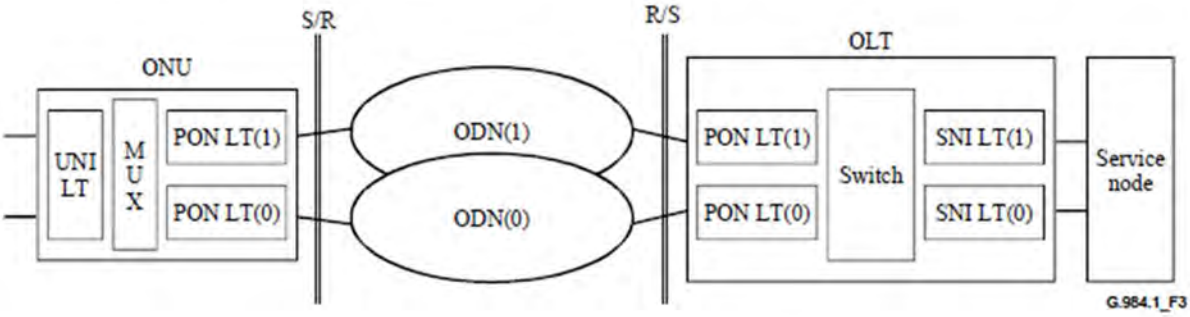
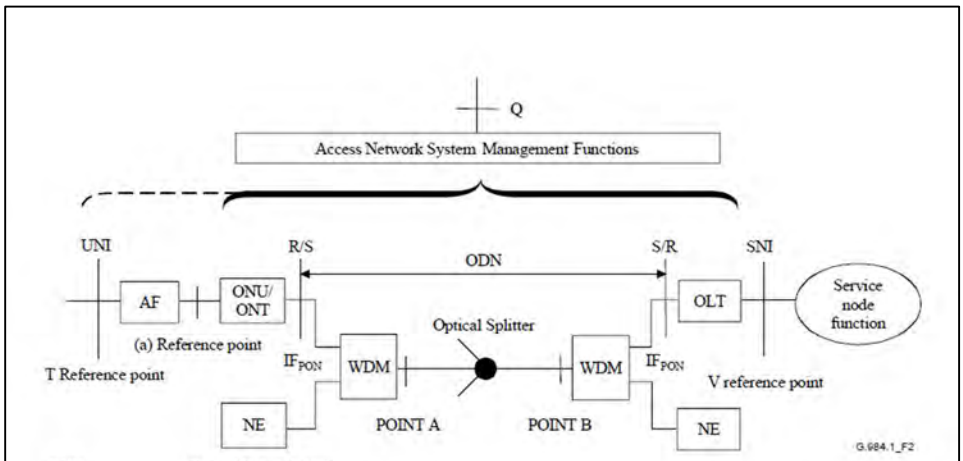


Figure 3a – Duplex system model

305. While Fig. 3a depicts the PON LT, the switch, and the SNI LT as part of the "OLT," a POSITA would understand that the PON LT is functioning as the OLT of Claim 7. This is further shown by Fig. 2 of G.984.1, which depicts the SNI as outside of the OLT. Ex. 1011, 12.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
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Figure 2 – Reference configuration for GPON

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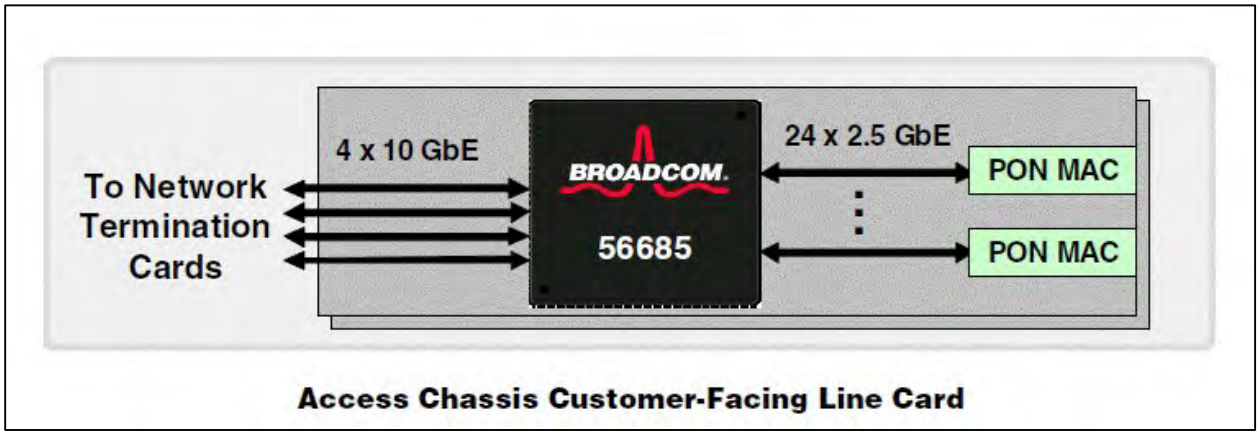
306. Regardless, the '142 patent contemplates that the aggregation switch and the OLT could be contained within the same physical device. And Fig. 3a shows that a switch that is serially connected between the device that is performing the digital to optical conversion, the PON LT, and the broader network, which would include a PON interface router. *See* Claim [5.A].

307. Additionally, BCM56685 teaches the use of an aggregation switch between the OLT and a PON interface router. BCM56685 is a publicly available product brief for a "108 Gbps Integrated Multilayer Ethernet Switch" chipset. This switch chip is advertised as being specifically designed for use with GPON. Ex. 1020 at 2 ("With its 2.5 Gbps interfaces the BCM56685 is tailored for direct interfaces to GPON ports and dense DSL line cards, minimizing total system power, board area, and solution cost."). The figures also show that the advertised chip is designed to exist between network termination cards and a PON.



C. Claim 4 – The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said

aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT

308. *See* Claim 7.

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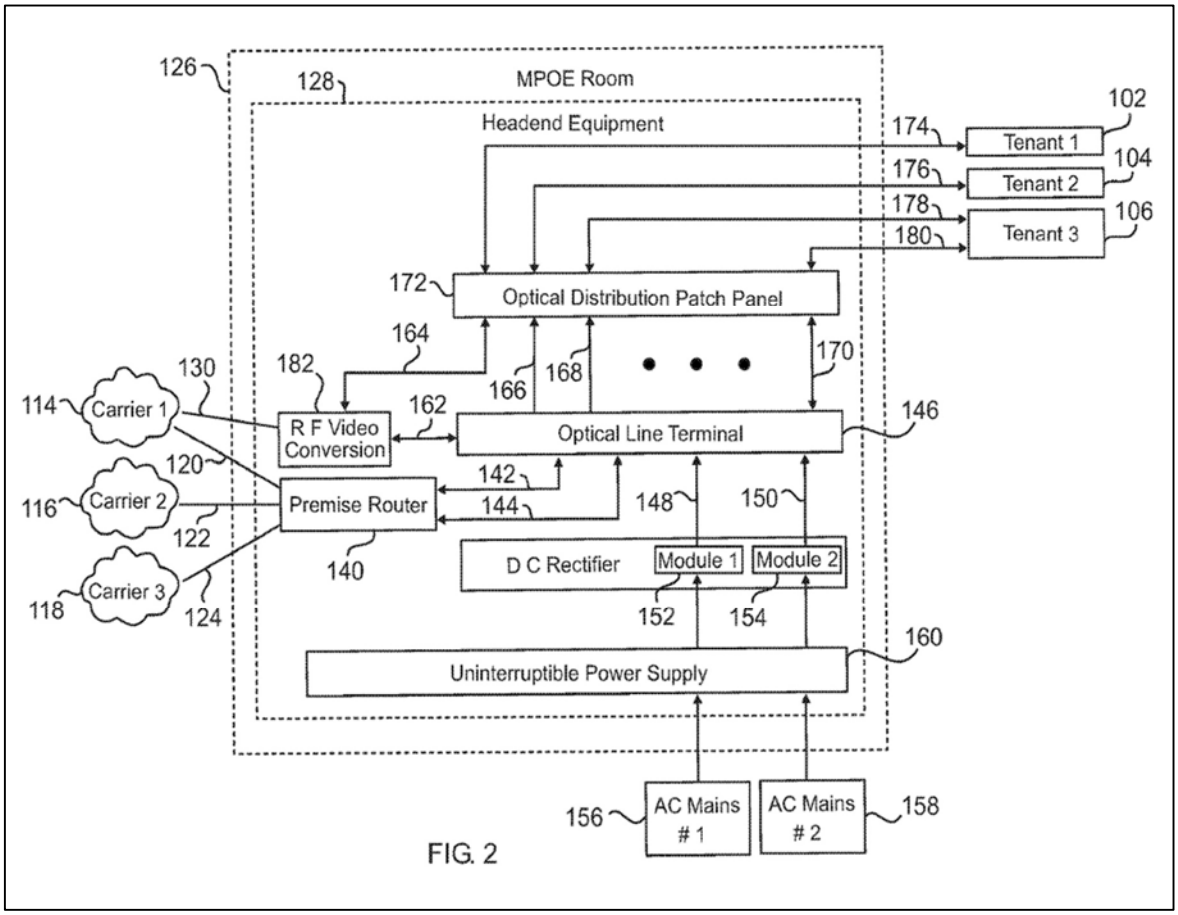

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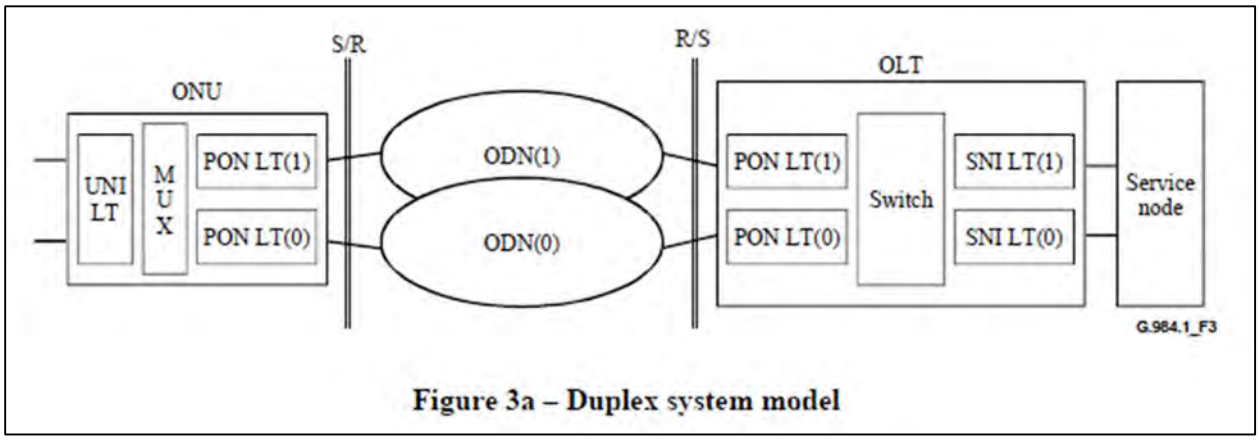

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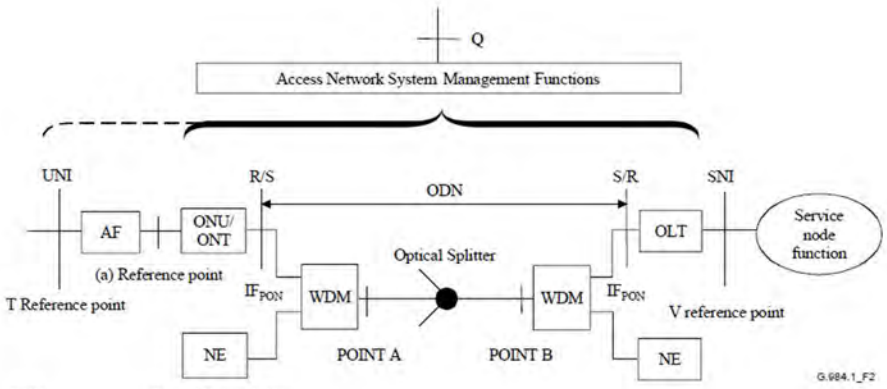

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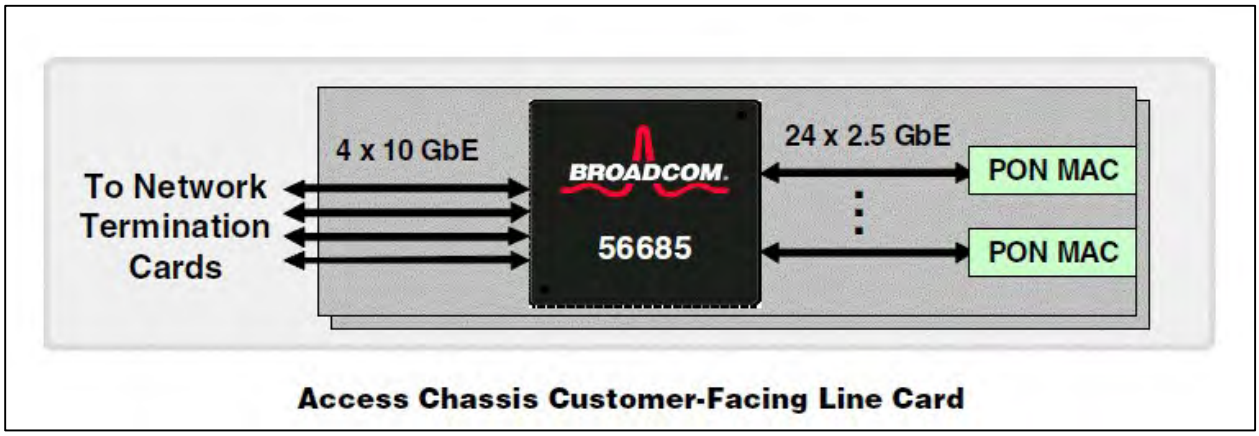

XIV. Ground 3: The combination of G.984.1 in view G.984.3, RFC 4364, and Ravindran renders claims 1-9 obvious.

314. As I discuss below, a POSITA would have known how to combine PONs (as discussed in G.984.1 and G.984.3) with VPNs using VRFs (as discussed in RFC 4364), and would have been motivated to do so to provide scalable VPN services on PONs (as discussed in Ravindran) based on the disclosures of G.984.1, G.984.3, RFC 4364, and Ravindran. Therefore, all of the claims of the ’142 patent are obvious in light of the combination of G.984.1, G.984.3, RFC 4364, and Ravindran.

A. Motivation to Combine

315. A POSITA would have been motivated to combine G.984.1, G.984.3, RFC 4364, and Ravindran to use a VRF-based virtual data separation (as discussed

in RFC 4364, and Ravindran on a "Content Oriented Network" ("CON") that delivers content to end users at ONUs using as a fiber optic network such as a PON as described in G.984.1 and G.984.3.

316. As discussed above, PON architecture, as discussed in G.984.1 and G.984.3 uses a single fiber optic cable to connect multiple end users (using ONUs such as those discussed in Ravindran) to a network. According to Ravindran, a POSITA would have been motivated to use VRF over a PON at least to provide stringent "performance, security, and/or reliability" requirements for distributing media content to geographically distributed end users. Ex. 1016, [0028]. Ravindran further states that these benefits can be provided to customers using ONUs that are known components of PONs. *Id*., [0031].

317. A POSITA would have had a reasonable expectation of success, because data that was virtually separated using VRF could be transported to end users across an optical network to ONUs, such as using a PON.

318. As discussed above, PONs were known for at least a decade prior to the '142 patent. For example, the GPON standard was finalized and published by the ITU-T in 2003. Ex. 1030, ¶ 41. APON/BPON technologies preceded EPON, and those standards (G.983.1-4) were first published in 1998. *See generally* Ex. 1025. VRF is a software-based technology that allows a single router to simultaneously maintain more than one routing table for transmitting content to different end user

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locations on a network (each end user location has a different routing table at the router). VRF enables one physical device to act as multiple routers and can route data to multiple end points along a single communication line (e.g., a single optical line). Because the data separation is "virtual," VRF data separation does not require any specific physical structure to configure a service provider router to virtually separate data intended for different end users. For example, Ravindran teaches that a POSITA would have known to distribute virtually separated data streams separated by VRF over a CON that connects to end users connected to the network using ONUs, and so a POSITA would have been motivated to use a VRF as discussed in RFC 4364 and Ravindran over a PON as discussed in G.984.1 and G.984.3 for providing data to an ONU as discussed in Ravindran. For example, RFC 4364 describes a method by which a Service Provider uses an IP backbone (such as a CON, as discussed in Ravindran) to provide IP Virtual Private Networks (VPNs) for its customers through the use of VRF. Ex. 1016, ¶¶ [0027], [0031].

319. As discussed herein, VRF technologies can be used to virtually separate content for different end users on any type of network. For example, a PON is agnostic to whether traffic has been "virtually" routed or routed by distinct routers upstream of the router (e.g., OLT) communicating data to one or more ONUs.

320. Ravindran discusses distributing data streams separated by VRF over a PON. More specifically, Ravindran discusses VRF as part of a CON architecture

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that supports secure and efficient content delivery within virtual private groups. *Id.* Ravindran's system maps "existing transport virtualization constructs, such as VPN Routing and Forwarding Table (VRF), virtual router (VR), and/or Virtual Private Local Area Network Service (VPLS) constructs," allowing service providers to manage multiple VPNs and to provide "virtual separation of the control and data transport among the hosted VPNs, customized Traffic Engineering (TE) and QoS [Quality of Service] to meet the individual needs of the VPNs, and security of data traversing between the VPNs sites." *Id*., [0070], [0073]. This aligns with Ravindran's goals of secure and scalable content delivery in a content-oriented network.

321. Ravindran discusses that the foregoing benefits of VRF are achieved with optical infrastructure for deploying the proposed content-oriented networking system to deliver content to ONUs. According to Ravindran, "customer nodes may also comprise customer equipment (not shown) that may be configured to receive content from the CON 110, e.g., via access networks, and distribute the content to a plurality of customers 112." Ex. 1016, [0031]. Ravindran further notes that the "customer nodes may comprise optical network terminals (ONUs)." *Id*. A POSITA would have been motivated to use a PON architecture as described in G.984.1 and G.984.3 for the content-centric model described in Ravindran, because Ravindran's framework allows "the CON to formulate specific policies for each of the VPGs

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[e.g., VPNs], offer customized treatment and realize the policies using building blocks to support VPGs in the CON" (Ex. 1016, [0030]), Ravindran explains that these benefits are usable with ONUs known to be connected with a PON. *Id*., [0031].

322. A POSITA would have been motivated to use VRF as described in RFC 4364 with a passive optical network (PON) (as described in G.984.1 and G.984.3) to implement the CON architecture described in Ravindran to achieve logical separation of traffic over a shared physical infrastructure that communicates with ONUs, which aligns with Ravindran's goals of secure and scalable content delivery in a CON. Ravindran explains that VRF can be used for delivering content to ONUs. A POSITA would have had a reasonable expectation of success in combining G.984.1, G.984.3, RFC 4364 and Ravindran, because a GPON delivers data to end users over optical networks (similar to the CON discussed in Ravindran) by aggregating data destined for multiple ONUs into an aggregated data feed, and each ONU is configured for identifying only those data packets relevant to it, and to discard data packets destined for other ONUs. A POSITA would be motivated to use VRF to limit the number of physical devices that are required to provide VPNs with different requirements." Ravindran, [0029] ("The CON may be based on a framework, e.g., a [*sic*] infrastructure, that allows VPGs of different requirements to coexist on the CON.")

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323. A POSITA would have been motivated to look to prevalent PON standards of the time (GPON, as discussed in G.984.1 and G.984.3) for additional information regarding PONs and the relevant VRF documentation (RFC 4364) for additional information regarding VRF, for providing VRF functionality over a PON.

B. Claim 5

1. [5.PRE] A digital network communication method comprises:

324. To the extent the preamble is limiting, a POSITA would have understood the G.984.1, RFC 4364, and Ravindran combination teaches this limitation.

325. The '142 patent discloses that components of a system are "used to provide a mutually secure, shared Local Area Network ("LAN") implementation which can supply a multi-tenant site such as an office building 100 with converged voice, data and video signal traffic at gigabit speeds to a plurality of mutually secure end point users such as building tenants having multiple end user devices such as computers, access points and wireless controllers, application servers and printers, and television sets." Ex. 1001, 3:62-4.

326. Digital data network communication methods are nothing new and are the subject of many standards. G.984.1 discloses a digital data network communication method. For example, G.984.1 describes a passive optical network, which is a network that is used for digital communications. Ex. 1011, *generally*.

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G.984.3, a companion to G.984.1, also describes a network that is used for digital communications. Ex. 1013, *generally*. These networks transmit data digitally, using digital light signals transmitted across optical fibers. *See id*., 20 (describing laser "bursts" that transmits a digital pattern of zeros and ones into the optical fiber).

327. RFC 4364 also describes a digital data network communication method that describes how "[d]ata packets are tunneled through the [IP] backbone" between end points. Ex. 1014, 1.

328. Lastly, Ravindran discloses a "content oriented network (CON)" that provides digital data to users from caching/storing devices on the network. Ex. 1016, [0027], [0031].

2. [5.A] receiving from at least one passive optical network (PON) interface router out of a plurality of PON interface routers at a PON optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices;

329. A POSITA would have understood the G.984.1, G.984.3, RFC 4364, and Ravindran teach this limitation.

330. The ’142 patent explains that the PON interface routers “can be configured with Virtual Routing and Forwarding (VRF)” and “Virtual Local Area Network (VLAN) tagging” to “separate and manage the distribution of voice, video and data content traffic to each of the users.” Ex. 1001, 4:52-56. This allows “data traffic intended for one tenant is automatically isolated from traffic intended for other tenants.” *Id*., 5:50-52. The ’142 patent describes the functionality of an OLT for receiving a plurality of data streams from a PON including a private data stream that has been virtually separated using the above-mentioned VRF with respect to figure 4 and which includes IP data packages. The ’142 patent explains that Figure 4 (reproduced below) “represents the Passive Optical Network infrastructure which is an optical distribution network used to convey the photonic broadcast stream feeds that contain the encrypted data packets such as VLAN-tagged ethernet frames.” Ex. 1001, 6:58-62. Those data packets are part of telecommunications service traffic that includes Internet, public switched telephone networks, and broadcast/cable television to ONUs that service at least one private user. *Id*., 4:23-26.

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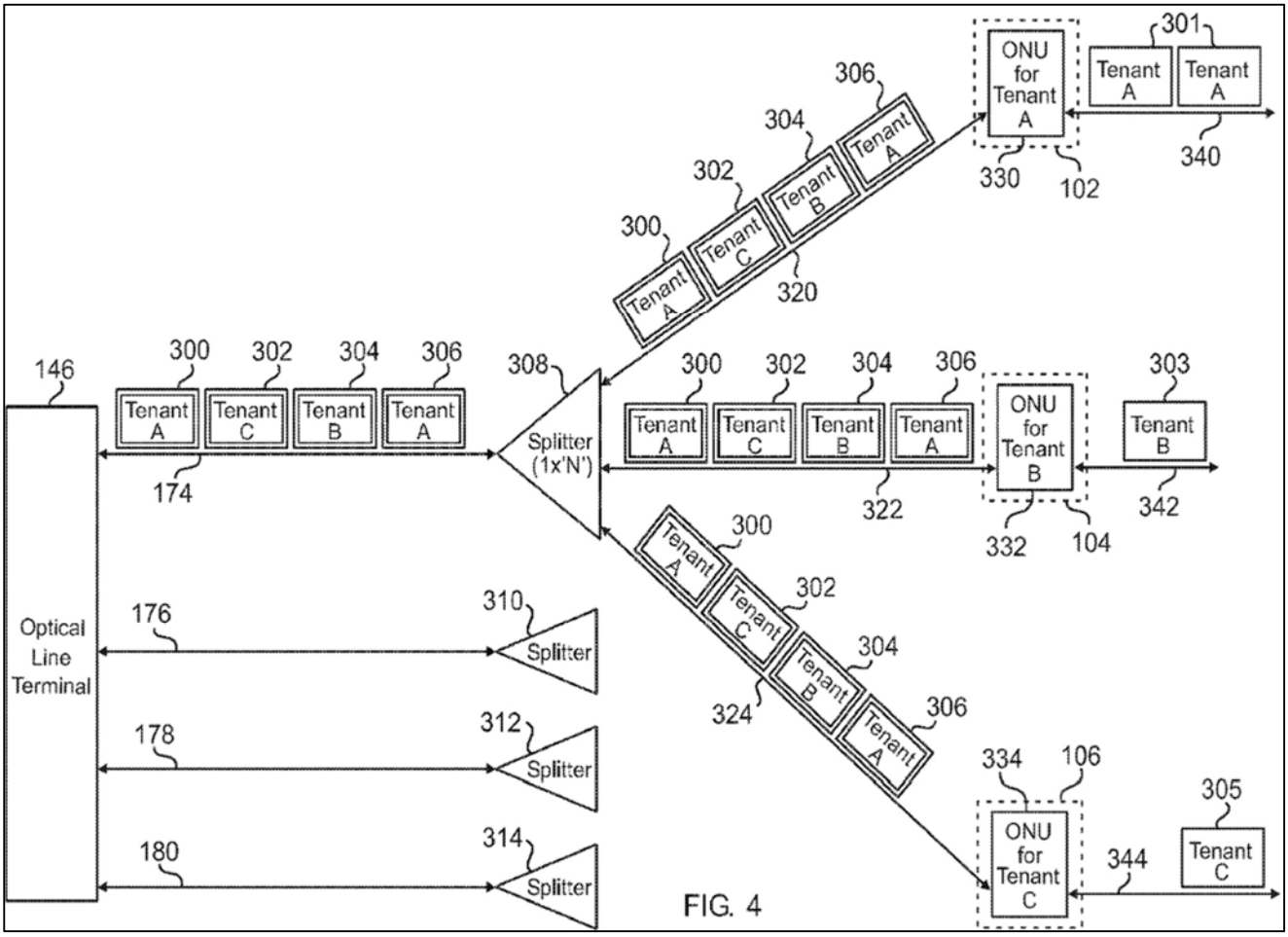

331. As shown, the OLT is connected with the "service node," which is the edge router of the PON (functionally, the "PON interface" router) so the OLT receives data streams transmitted from the PON, through an appropriate router. *Id.* The OLT is also connected to ONUs (although one is shown above, the "optical splitter" connects to multiple ONUs using the configuration shown in Figure 4, above). *Id*.

332. The PON (as discussed in detail in G.984.1-3) is agnostic to the data transmitted through it. RFC 4364 discloses transmitting at least one private data

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stream out of a plurality of data streams over a network, and Ravindran explains that a VRF-based VPN can be used to provide private data streams to an ONU, which teaches that a VRF-based VPN as described in RFC 4364 can be implemented across a PON (which connects to an ONU), as disclosed in G.984.1-3. Ex. 1014, 1; Ex. 1016, [0031].

333. The private data stream disclosed in RFC 4364 has been virtually separated using VRF to form at least one virtually separated private data stream. As discussed above, RFC 4364 is directed to "a method by which a Service Provider uses an IP backbone to provide IP Virtual Private Networks (VPNs) for its customers." Ex. 1014, 1. RFC 4364 describes a "'peer model', in which the customers' edge routers (CE routers) send their routes to the Service Provider's edge routers (PE routers); there is no 'overlay' visible to the customer's routing algorithm, and CE routers at different sites do not peer with each other." *Id*. Thus, the data streams discussed in RFC 4364 are "private" using the described VPN configuration. RFC 4364 describes a first PE router forwards/tunnels an IP packet within a MPLS packet to "the next hop," such as a second PE router "where the VPN label will be examined. *Id*., 25. RFC 4364 describes implementing VRF within the PE routers to virtually separate traffic into one or more virtually separated private data streams. The treatment of a packet received at the second PE router depends on the VPN route label of the received packet in the at least one virtually separated private data stream

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of the received plurality of data streams. *Id*. The second PE "may only be able to determine that the packet's destination address needs to be looked up in a particular VRF before being forwarded to a CE device." *Id*. As explained in Section 3 of RFC 4364:

> Each PE router maintains a number of separate forwarding tables. One of the forwarding tables is the "default forwarding table". The others are "VPN Routing and Forwarding tables", or "VRFs.

Ex. 1014, 9.

334. Moreover, Section 5 of RFC 4364 provides a detailed description of process for virtually separating a private data stream and forwarding the same to the intended private user device. This section includes a step-by-step logic flow of how a PE router handles an IP packet received from a CE device for forwarding to another CE device associated with an intended recipient:

335. First, a PE router receives an IP packet from a CE router. Ex. 1014, 23. The PE router then "chooses a particular VRF in which to look up the packet's destination address." *Id*. This is the first step in the claimed "virtual separation."

336. Next, the PE router looks up the packet's destination IP address of the "at least one private user device" in the located VRF. Assuming a match is found, the PE learns the packet's "next hop" (i.e., the CE router destined to receive the IP packet. *Id*., 23-24. Because the packet is sent over a VPN, the PE router does not

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perform a lookup in the main routing table or any other customer's VRF. The routing table used to lookup the CE router and IP address is the claimed "independently unique virtual routing table."

337. Based on the result of that VRF lookup, the PE router determines the next hop and, when the next hop requires passing the packet across the main backbone, the PE router encapsulates the packet (e.g., using an MPLS label) for transport across the provider's network to the packet's destination address. The encapsulation discussed in RFC 4364 creates at least one virtually separated private data stream comprising one or more Internet Protocol (IP) data packages that is a "virtually separated private data stream" isolated from all other traffic and intended for an ONU that serves at least one private user device of a plurality of ONUs. *Id*., 24. The plurality of ONUs serve a plurality of user devices. Accordingly, RFC 4364 explains that a PE router (e.g., of a PON) can virtually separate at least one private data stream comprising IP data packages intended for at least one ONU serving at least one private user device of a plurality of ONUs from a plurality of data streams as recited in [5.A], and the virtually separated data streams, including the at least one private data stream can be subsequently received at an OLT.

338. Ravindran also discloses that a PON distributes traffic that has been separated using VRF to end users associated with ONUs. Ravindran explains that content is provided from a plurality of carriers (as shown as VPG-A, VPG-B, and

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VPG-C in Figure 13, below) using virtually divided into Virtual Private Groups (VPGs)[8] to provide content to a plurality of users with optical network terminals (ONUs). Ex. 1016, [0031], [0069]. Ravindran uses a generic term for the network – denoting the network as a "Content Oriented Network (CON)" that handles and services data distribution for a plurality of VPG instances by virtually separating the data shared in each VPG instance. Ex. 1016, [0028], [0035]. Ravindran explains that the above-mentioned VPGs can be implemented by a CON that is configured to "map existing transport virtualization constructs, such as VPN Routing and Forwarding Table (VRF), virtual router (VR), and/or Virtual Private Local Area Network Service (VPLS) constructs, which may be used in current networks or technologies." Ex. 1016, [0070]. The VRF virtually separates data streams intended for different private user devices with ONUs. As shown in Figure 13 (reproduced below), each VPG instance is mapped to a respective VRF instance, and the CON receives a plurality of packets associated with each VPG instance, and they are then mapped to the appropriate VRF instance. Ex. 1016, [0071].

[8] Ravindran explains that a VPG is a more generic term for VPN. Ex. 1016, [0031], [0069].

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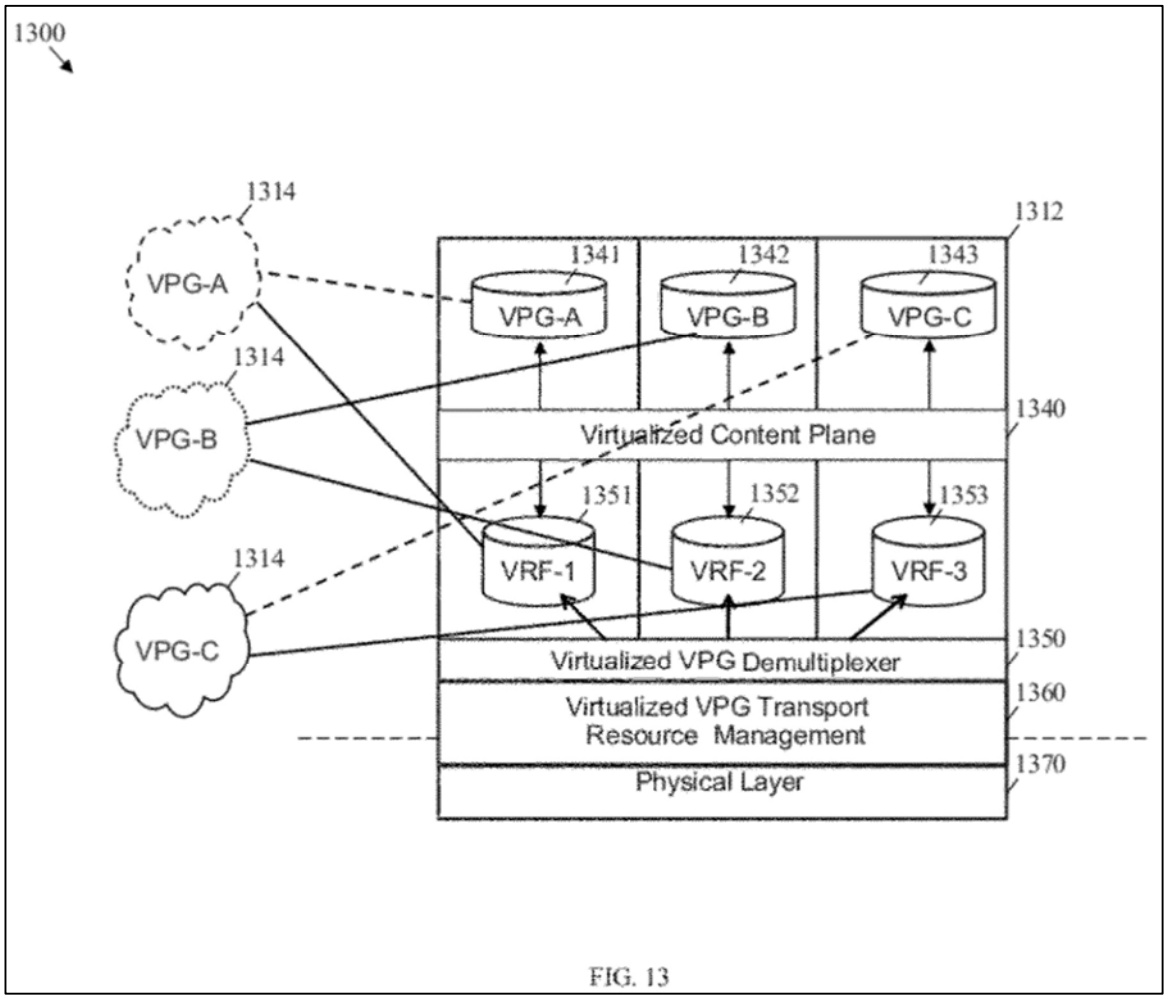

FIG. 13

339. As discussed above, a POSITA would have been motivated to combine the VRF teachings of RFC 4364 with the standardized PON architecture of G.984, including G.984.1 and G.984.3, so that content can be shared with an ONU, as described by Ravindran, so that a VPN using VRFs is implemented on a PON. The GPON standards are agnostic to the type of traffic that are received and, according to G.984.1, "GPON is required to support all currently known services and new services being discussed for residential subscribers and business customers, because of such a broadband capability." Ex. 1011, 12. As described above, Ravindran

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explains that a VRF can be used to provide data streams to an ONU (which includes providing data over a PON to the ONU). Further, a POSITA would understand that VRF could be used in a router device upstream of the PON OLT.

3. [5.B] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;

340. As shown in Figure 4 of the ’142 patent (shown above), data streams for multiple tenants (specifically, Tenant A, Tenant B, and Tenant C) are all included in a common data feed. Ex. 1001, 6:58-67. As the ’142 patent explains “the OLT can broadcast the combined encrypted VLAN-tagged ethernet frames 300, 302, 304, 306 over the distribution feeds 174, 176, 178, 180 to a number of splitters 308, 310, 312, 314.” *Id*.

341. G.984.1 describes the PON functionality of [5.B]. As shown in Figure 2 of G.984.1, shown below, signals are distributed to multiple end users using an optical splitter – a device that does not have any inherent ability to segregate different signals to different end users based on their intended end users. Instead, signals for any end user are included in the same signal, and the signal is split using the optical splitter so that all end users receive all data signals in a single data stream. *See* Ex. 1011, 12.

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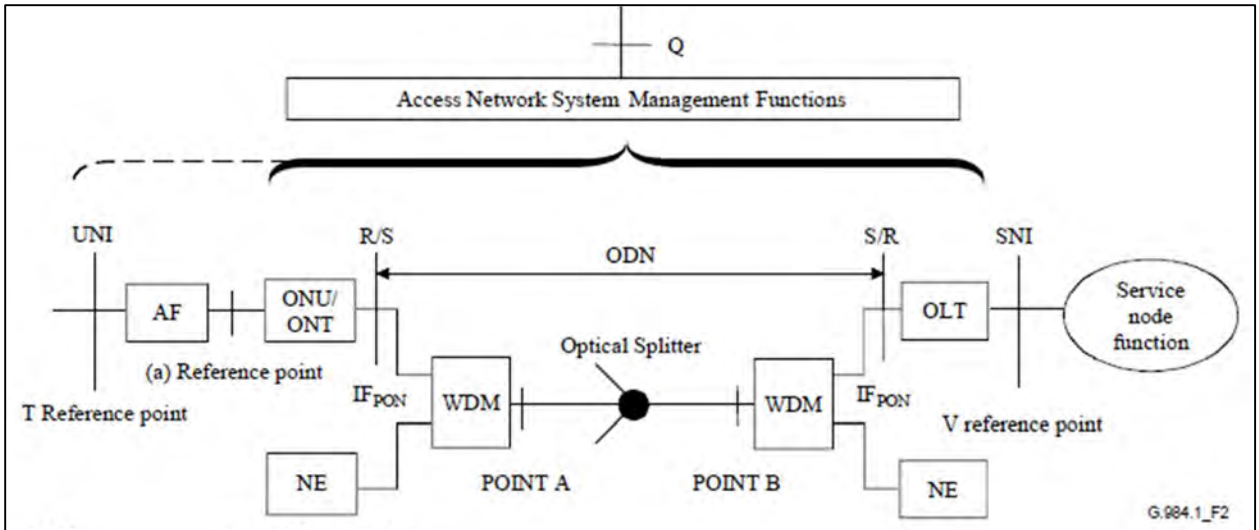

ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

342. G.984.3 provides more detail about how data for different ONUs can be aggregated onto a common data feed, using time division multiplexing and GEM Frame-IDs used by receiving ONUs to determine which data frames are relevant for the receiving ONU. Ex. 1013, 17.

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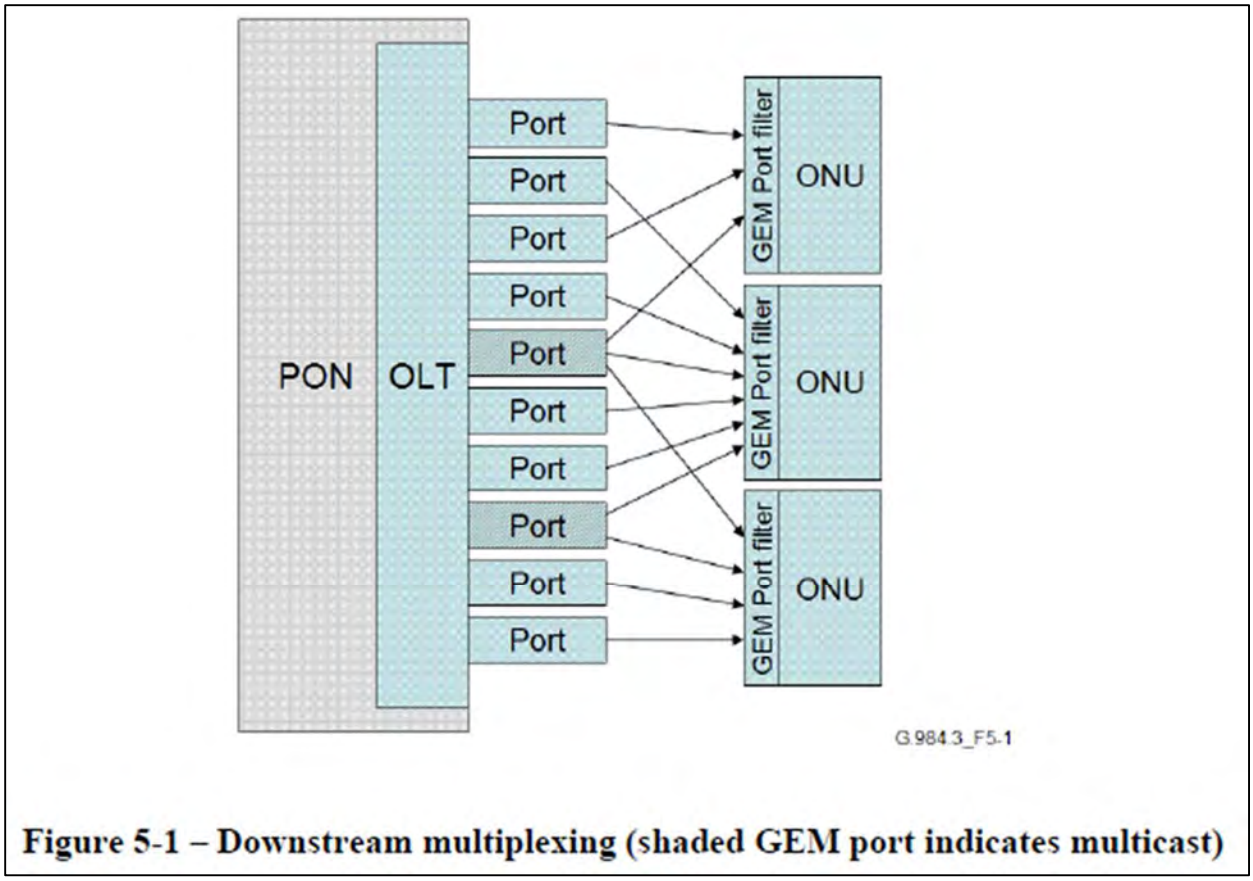

Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

Ex. 1013, 17.

4. [5.C] distributing said common data feed to said plurality of ONUs;

343. As discussed above, G.984.1 and G.984.3 describes that the common data feed is distributed to a plurality of ONUs using the optical splitter that directs identical optical signals along optical lines connected with each of the ONUs. Ex. 1013, 21.

344. For example. G.984.1 states that there are a plurality of ONUs that receive a common data feed from the OLT. Ex. 1011, 12.

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345. GPON systems are characterized, in general, by an optical line termination (OLT) system and an optical network unit (ONU) or optical network termination (ONT) with a passive optical distribution network (ODN) interconnecting them. There is, in general, a one-to-many relationship between the OLT and the ONUs.

346. This general architecture is depicted throughout G.984.1.

I.2 Typical system architectures

Figure I.1 shows a generic GPON system. This is developed more specifically in Figures I.2 to I.7.

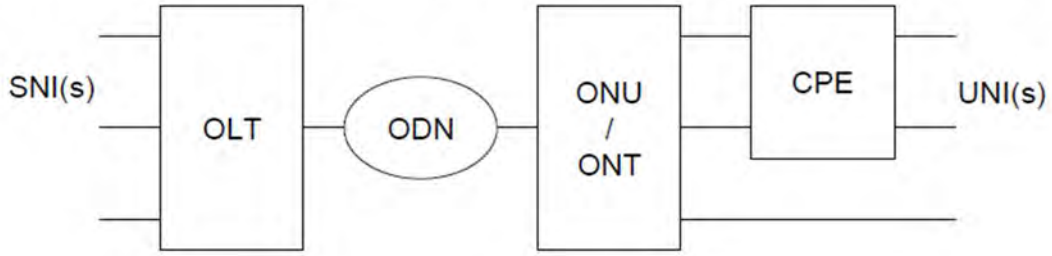

Figure I.1 – Generic GPON system

Ex. 1011, 20.

347. G.984.3 discloses a one-to-many configuration for connecting an OLT to a plurality of ONUs at least in Fig. 5-1.

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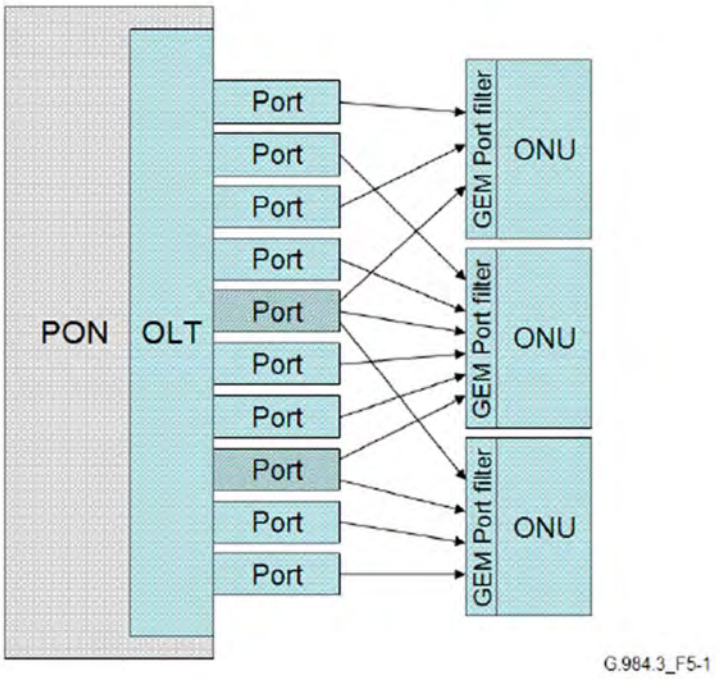


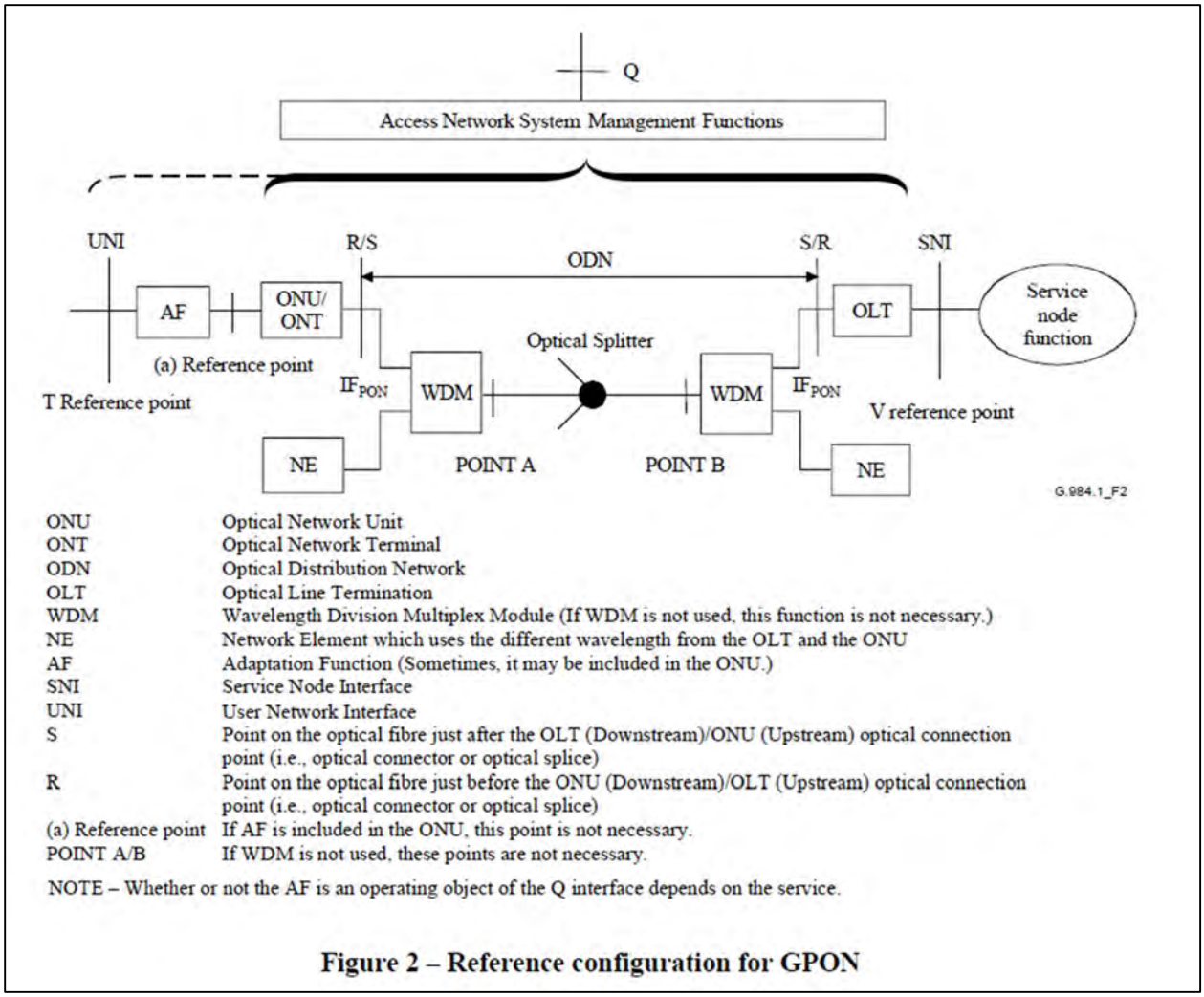
Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

Ex. 1013, 17.

5. [5.D]/[5.E] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;

348. As discussed above, G.984.3 discloses an optical splitter that replicates the common data feed and is connected to said plurality of ONUs. *Id*.

349. Figure 2 of G.984.1 depicts the optical splitter.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
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S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
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(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

350. The splitter and the allowable split ratio is further discussed within G.984.1. *Id*., 13. For example, it teaches that "split ratios of up to 1:64 are realistic for the physical layer, given current technology." *Id*. Here, the ratio is the number of ONU's (64) that can be connected with a single (1) OLT port. The "split" in "split ratio" refers to the use of optical splitters, that replicate the data feed to all of the ONUs connected with the splitter. *Id*. ("a larger split ratio implies greater optical splitting").

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351. G.984.3 confirms the use of optical splitters to distribute signals from the OLT to a plurality of ONUs. Ex.1013, 22.

6. [5.F] delivering said common data feed to said plurality of ONUs;

352. As discussed above, the optical splitter of G.984.1 and G.984.3 is connected with optical lines connected with each respective ONU, so that the common data feed is replicated and delivered to each of the plurality of ONUs. *See* Ex. 1011, 12. As discussed, G.984.1 contemplates that at least 64 ONUs can be connected to a single OLT port. *Id.*

7. [5.G] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;

353. The '142 patent explains that "[e]ach ONU 330, 332, 334 is operated so that it utilizes the VLAN-tagging to select those of the incoming ethernet frames assigned to the particular tenant, and then removes the encryption from the selected ethernet frames." Ex. 1001, 7:22-25.

354. G.984.1 and G.984.3 discloses limitation [5.G]. GPON, as described in G.984.1 and G.984.3, utilizes the data transport scheme known as GPON Encapsulation Method (GEM), to send data from the OLT to ONUs. Ex. 1013, 15-16. According to G.984.3 "GEM provides a connection-oriented, variable-length framing mechanism for transport of data services over the passive optical network

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(PON) and is independent of the type of the service node interface at the OLT as well as the types of UNI interfaces at the ONUs." *Id*. G.984.3 further explains that "IP packets are carried directed in the GEM frame payload." *Id.*, 128.

355. G.984.3 further explains that a given ONU only extracts the GEM frames that have been specifically addressed to that ONU despite the fact that the ONU receives the GEM frames for other ONUs that are part of the common data feed.

> In the downstream direction, the traffic multiplexing functionality is centralized. The OLT multiplexes the GEM frames onto the transmission medium using GEM Port-ID as a key to identify the GEM frames that belong to different downstream logical connections. Each ONU filters the downstream GEM frames based on their GEM Port-IDs and processes only the GEM frames that belong to that ONU.

Ex. 1013, 17.

356. As such, G.984.3 teaches that at least one of the ONUs extracts the virtually separated data stream that includes IP data packages from the common data feed that is received over the ODN.

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8. [5.H] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.

357. The ’142 patent explains that once ONU-specific data feeds are decrypted, they are “then made available 340, 342, 344 for the tenant’s IP/ethernet end-user equipment. Ex. 1001, 7:27-29.

358. As discussed above in [5.G], G.984.1 and G.984.3 discloses that a given ONU extracts only the IP packages from a GEM frame where the GEM port ID matches the ONU. The purpose of extracting that IP package is to send the IP package (in the at least one virtually separated private data stream) from the at least on ONU to the at least one private user device that is connected to that ONU of the plurality of user devices, while discarding any data that is intended for user devices connected to different ONUs. The purpose of an access network, such as the one described by G.984.1-3, is to provide access to user devices to a wider network, such as the internet or other IP networks. G.984.1 teaches a “User Network Interface” that exists downstream of an ONU, such as gigabit ethernet. Ex. 1011, 20. This is depicted in Fig. I.1.

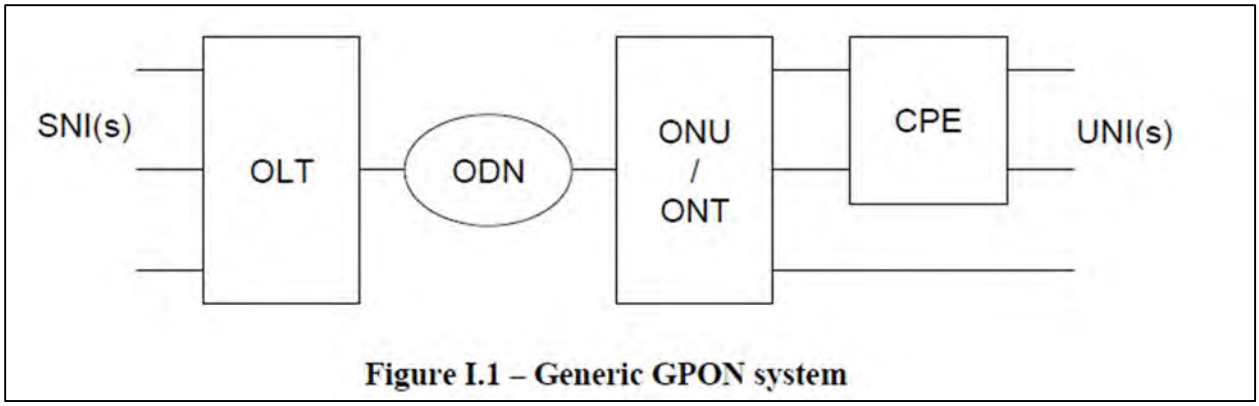

Figure I.1 – Generic GPON system

Id., 20.

359. G.984.1 further describes that "[i]n the ONT, Ethernet frames as defined in [b-IEEE 802.3] are extracted from the TC layer. In some ONTs, the Ethernet layer is quite abbreviated and little processing is done on the frames from their reception on the GPON interface to their transmission on the UNI." *Id*., 26. G.984.1 further notes that "[i]n some ONTs, some sort of VLAN processing is done, as defined in the IEEE 802.1-series of standards." *Id.* G.984.1 further explains that this can be to identify the specific user by a VLAN-ID.

> This typically involves adding tag(s) in the upstream, and removing tag(s) in the downstream, for the purpose of identifying each user/service packet via their VLAN-ID. However, this is not necessary in all cases, since the PON itself has the GEM port-ID mechanism for such identification.

Id.

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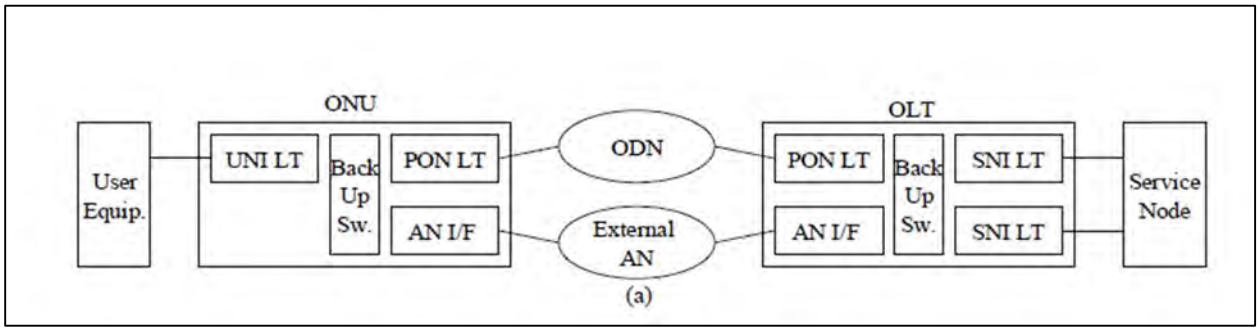
360. G.984.1 further confirms that user equipment is downstream of an ONU.



361. Ex. 1011, 34.

C. Claim 6 - The method of claim 5, wherein said at least one of said plurality of ONUs provides services to at least one private user of a plurality of users.

362. As discussed in reference to [5.H], the '142 patent explains that services (e.g., Internet, public switched telephone networks, and broadcast/cable television) are provided to a tenant (of a plurality of tenants, as shown in Figure 4 of the '142 patent). Ex. 1001, 4:23-26, 7:25-29.

363. G.984.1 discloses this, explaining that services are provided, according to a service node interface to an OLT that provides the services to the end user at the ONU. More specifically, Table I.2 describes UNIs and services that are provided to downstream users.

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Examples of UNIs, physical interfaces and services that they provide are shown in Table I.2.

Table I.2 – Examples of UNI and services

UNI (Note 1)	Physical interface (Note 2)	Service (Note 3)
10BASE-T ([b-IEEE 802.3])	–	Ethernet
100BASE-TX ([b-IEEE 802.3])	–	Ethernet
1000BASE- T ([b-IEEE 802.3])	–	Ethernet
[b-ITU-T I.430]	–	ISDN (BRI)
[b-ITU-T G.703]	PDH	DS3, ATM, E1, E3
[b-ANSI T1.102], [b-ANSI T1.107]	PDH	T1, DS3
NOTE 1 – There are many other services accommodated in GPON, but those services do not have specified UNIs. NOTE 2 – Each item in the "physical interface" column is illustrated by the corresponding entry in the "UNI" column. NOTE 3 – The column labelled "service" shows which services can be supported by the physical interface.		

364. This is also illustrated in G.984.1's Figure 2, reproduced below, which shows that the PON connects the user network interface to a service node function.

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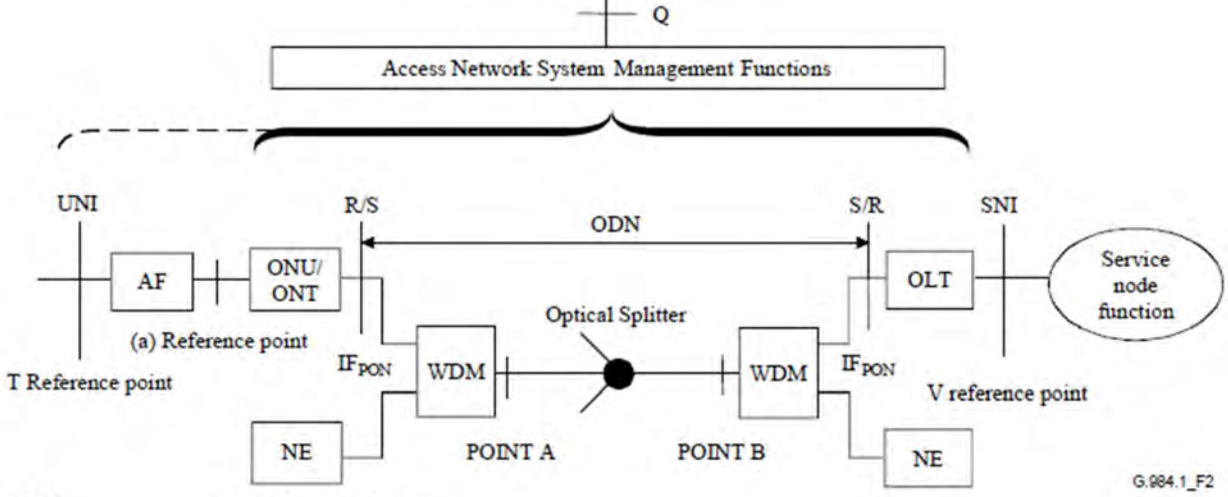

ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

365. As a result, the services are provided to said at least one of said plurality of ONUs, which provides the services to the at least one private user connected to the ONU, of the plurality of users.

D. Claim 7 - The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually

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separated private data stream comprising said IP data packages to said PON OLT.

366. The '142 patent states that "an aggregation switch [is] referred to as an Optical Line Terminal (OLT)." Ex. 1001, 4:34-38.

367. G.984.1 discloses this claim, by explaining that an OLT includes an aggregation switch and a PON Line Terminal (PON LT) in serial connection with the aggregation switch. Ex. 1011, 14. G.984.1 discloses switches located between a service node interface and PON Line Termination (PON LT), to be connected in series with the PON Line Termination. *Id*. The switch delivers the plurality of data streams from the service node (which includes the virtually separate private data stream containing the IP data packages, received from the service node, as discussed above).

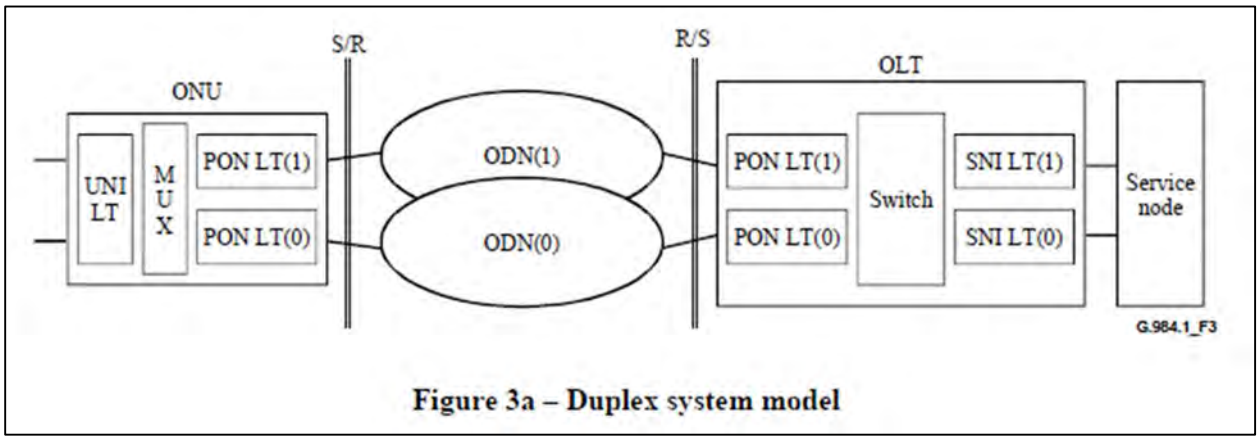

Figure 3a – Duplex system model

368. While Fig. 3a depicts the PON LT, the switch, and the SNI LT as part of the "OLT," a POSITA would understand that the PON LT is functioning as the

OLT of Claim 7. This is further confirmed by Fig. 2 of G.984.1, which depicts the SNI as outside of the OLT.

369. Regardless, the '142 patent contemplates that the aggregation switch and the OLT could be contained within the same physical device. And Fig. 3a shows that a switch that is serially connected between the device that is performing the digital to optical conversion, the PON LT, and the broader network, which would include a PON interface router. *See* Claim [5.A].

E. Claim 8

1. [8.PRE] A digital network communication method comprises:

370. To the extent the preamble is limiting, a POSITA would have understood the G.984.1, G.984.3, RFC 4364, and Ravindran combination teaches this limitation for at least the same reasons as discussed in reference to Claim 5.

371. See limitation [5.pre].

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2. [8.A] receiving at a passive optical network (PON) optical line terminal (OLT), at least one private data stream out of a plurality of data streams, wherein said at least one private data stream has been virtually separated using Virtual Routing and Forwarding (VRF) to form at least one virtually separated private data stream comprised of Internet Protocol (IP) data packages, and wherein said at least one virtually separated private data stream including said IP data packages is intended for at least one of a plurality of ONUs, and wherein said at least one of a plurality of ONUs serves at least one private user device of a plurality of user devices;

372. See limitation [5.A]. The only difference between Claim [8.A] and [5.A] is that [5.A] includes a requirement that the OLT receive the at least one private data stream from a PON interface router. Claim [8.A] does not include this additional limitations and is therefore broader than Claim [5.A], and for those reasons discussed in reference to [5.A], G.984.1, G.984.3, RFC 4364, and Ravindran disclose the limitations of [8.A].

3. [8.B] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;

373. See Limitation [5.B].

4. [8.C] distributing said common data feed to said plurality of ONUs;

374. See limitation [5.C].

5. [8.D]/[8.E] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;

375. See limitations [5.D]/[5.E].

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6. [8.F] delivering said common data feed to said plurality of ONUs;

376. See limitation [5.F].

7. [8.G] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;

377. See limitation [5.G].

8. [8.H] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.

378. See limitation [5.H].

F. Claim 9 - The method of claim 8, wherein said at least one of said plurality of ONUs provides services to at least one private user our of plurality of users.

379. See Claim 6.

G. Claim 1

1. [1.PRE] A digital data network communication method comprises:

380. To the extent the preamble is limiting, a POSITA would have understood the G.984.1, G.984.3, RFC 4364, and Ravindran combination teaches this limitation.

381. *See* limitation [5.pre].

382. While claims 5 and 8 focus on providing data over a PON to an end user (e.g., from a network), Claim 1 describes an end-to-end process whereby data

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is first uploaded to the network (using a PON), transmitted across the network, and then provided to an end user via a PON. The steps for providing data to the end user via a PON are analogous to those recited in claims 5 and 8. As discussed below, the remaining limitations, including those limitations discussing the upload of data to a network using a PON and transferring data across a network are also nothing new.

2. [1.A] accepting a plurality of data streams into a primary passive optical network (PON) interface router, interconnected with a secondary PON interface router serving a plurality of user devices through a plurality of optical network units (ONUs);

383. A POSITA would have understood that the G.984.1, G.984.3, RFC 4364, and Ravindran combination teaches this limitation.

384. The '142 patent illustrates this limitation in Figure 2, reproduced below, which shows the "headend equipment 128 receives the plurality of telecommunications service carrier lines 120, 122, 124 from the separate carrier providers 114, 116, 118." Ex. 1001, 4:45-47. The signals received can include "VLAN-tagged voice, video and data content traffic connected to the Optical Line Terminal (OLT) 146 through an uplink 142 that provides primary communication." *Id*., 4:57-59.

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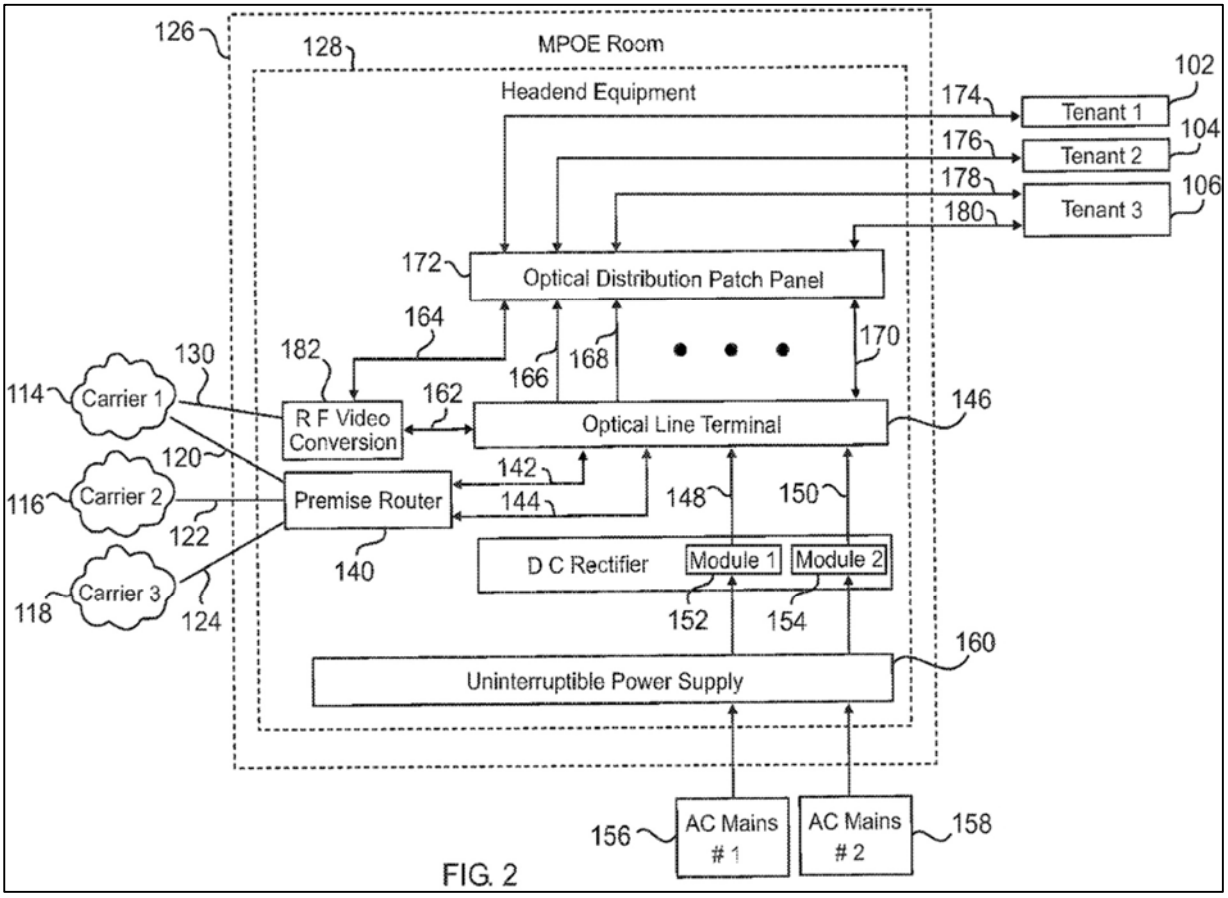

FIG. 2

385. RFC 4364 discloses limitation [1.A]. RFC 4364 explains that Service Provider's edge routers (PE routers) accept a plurality of data streams, for example, from a plurality of customers' edge routers (CE routers). Ex. 1014, 12, 23 (describing that multiple CEs may be attached to a PE, and explaining how to forward data received from a CE). The a PE router is claim 1's "primary passive optical network (PON) interface router" when implemented in a PON, and the first PE router tunnels to a second PE router connected with an intended destination of the data stream. The second PE router is claim 1's "secondary PON interface router" that services a plurality of ONUs. *Id*., 24.

386. A POSITA would have been motivated to combine RFC 4364 and G.984.1 and G.984.3 to implement VRF on a PON. Ravindran demonstrates why a POSITA would have been motivated to combine RFC 4364 with G.984.1 and G.984.3. Ravindran explains that content may be provided from a plurality of carriers (as shown as VPG-A, VPG-B, and VPG-C in Figure 13, below), and that content is provided to a plurality of users with optical network terminals (ONUs). Ex. 1016, [0031], [0069].

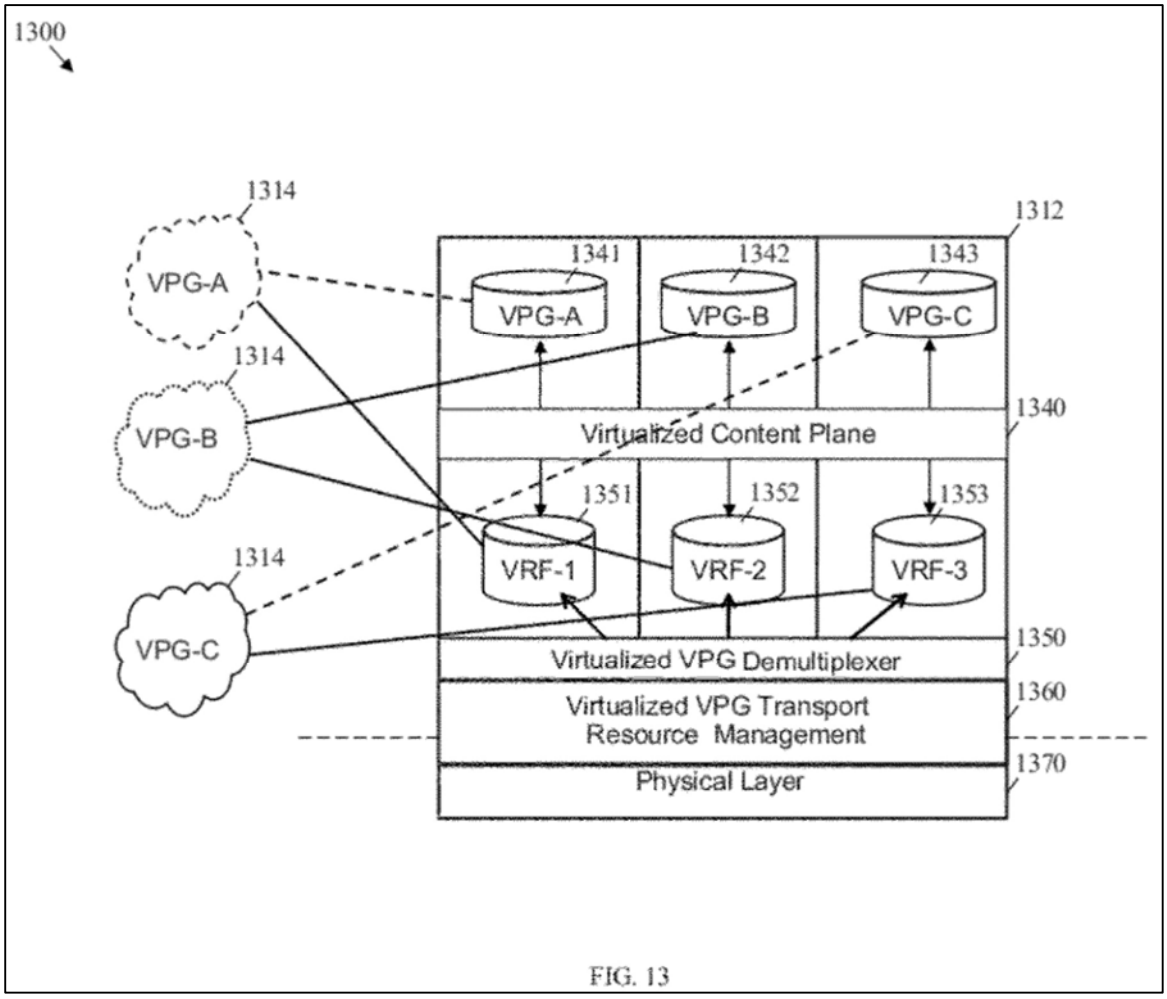

FIG. 13

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387. Therefore, a POSITA would have understood that a PE device of a PON-based system is configured to accept a plurality of data streams, and the PE device is interconnected with a CE device that is serving a plurality of user devices through a plurality of ONUs based on the disclosure of RFC 4264.

3. [1.B] configuring said primary PON interface router to virtually separate the information intended for at least one private user device of a plurality of user devices, wherein said at least one private user device of a plurality of user devices is connected to at least one of said plurality of ONUs;

388. RFC 4364 teaches [1.B].

389. The '142 patent explains that the PON interface routers "can be configured with Virtual Routing and Forwarding (VRF)" and "Virtual Local Area Network (VLAN) tagging" to "separate and manage the distribution of voice, video and data content traffic to each of the users." Ex. 1001, 4:52-56. This allows "data traffic intended for one tenant is automatically isolated from traffic intended for other tenants." *Id*., 5:50-52.

390. RFC 4364 provides information about how an MPLS-based VPN virtually separates information intended for at least one private user device of a plurality of user devices by configuring an OLT (or PE) using a VRF. Ex. 1014, 8. The PE is configured with a separate VRF for each PE—CE attachment circuit, and the VRF includes destination address information that is looked up when the PE

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receives information destined for user device connected to a CE (ONU) for which the information is directed. *Id*.

391. Ravindran also describes that user groups may be virtually divided into Virtual Private Groups (VPGs), such as VPNs, and the CON used to distribute data may be configured to handle and service a plurality of VPG instances by virtually separating the data shared in each VPG instance. Ex. 1016, [0028], [0035].

4. [1.C]/[1.D] wherein said configuring comprises: generating at least one independently unique virtual routing table by using Virtual Routing and Forwarding (VRF);

392. The '142 patent explains that the PON interface router "can be configured to run a routing table routing 412 that accesses the virtual routing table instantiations to create virtual routing tables 420, 422, 424, 426 for each Optical Network Unit (ONU) serving a tenant." Ex. 1001, 5:42-46. This is reflected in Figure 3, reproduced below. As explained by the '142 patent, this "supports the overlapping of IP addresses for any of the tenants because the routing instances are independent." *Id*., 5:46-50.

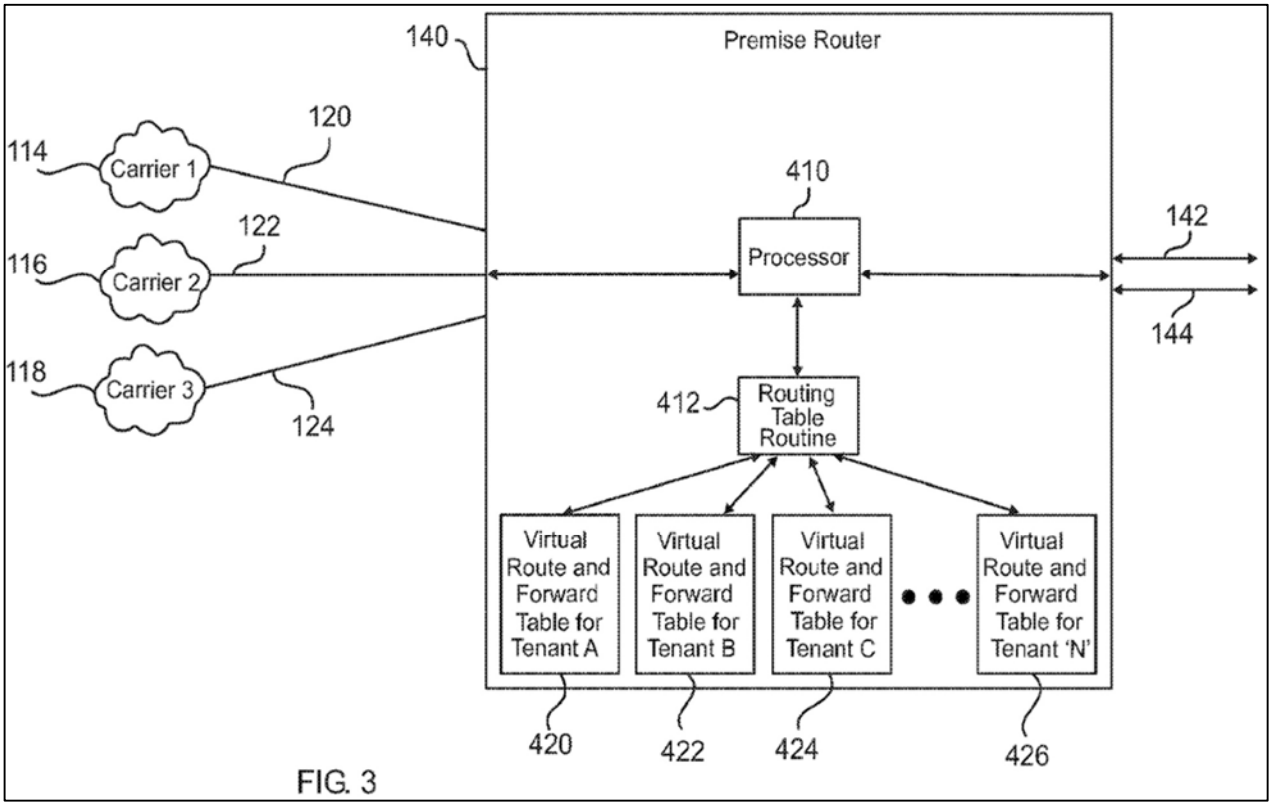

FIG. 3

393. The '142 patent also provides pseudo-code for generating and implementing virtual routing tables for each of a plurality of ONUs. I have added line numbers that correspond with the lines in Column 6 of the '142 patent for convenience:

[11] !---Begin gateway configuration and programming

[12] !---Configure gateway identity

[13] !---Establish express forwarding to optimize network per-

[14] formance and scalability

[15] !---For each tenant (1 . . . n) Do

[16] !---Instantiate virtual route table for the Tenant

[17] !---Enable VPN (Virtual Private Network) for the Tenant

[18] !---Establish routing and forwarding for the virtual rout-

[19] ing table

[20] !---Creates lists of import and export route-target

[21] extended communities

[22] !---End Do

[23] !---Set IP (Internet Protocol) address, netmask and enable

[24] IS-IS routing

[25] !---For each tenant (1 . . . n) Do

[26] !---Establish loopback identifier for the Tenant

[27] !---Enable VRF (Virtual Routing and Forwarding) for the

[28] Tenant

[29] !---Associate the VRF instance with an interface or sub-

[30] interface.

[31] !---Loopbacks use the same IP address because they

[32] belong to different Tenant VRF's

[33] !---Broadcast to all hosts on the subnet

[34] !---End Do

[35] !---Define and configure the gateway ingress interface

[36] !---Set bandwidth

[37] !---Config IP address and netmask

[38] !---Enable MPLS (MultiProtocol Label Switching)

[39] !---Enables logging of BGP (Border Gateway Protocol)

[40] neighbor resets.

[41] !---Adds an entry to the BGP or multiprotocol BGP

[42] neighbor table

[43] !---Enables BGP sessions to use a specific operational

[44] interface for TCP (Transmission Control Protocol) con-

[45] nections

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[46] !---Enter address family configuration mode

[47] !---Sends the community attribute to a BGP neighbor

[48] !---For each tenant (1 . . . n) Do

[49] !---Set the address family for the tenant

[50] !---End Do

[51] !---Use longest prefix matching or default route

[52] !---end gateway configuration and programming

Id., 6:11-52.

394. Lines 15-19 of the above pseudo-code detail the creation of independently unique virtual routing tables using VRF tables.

395. RFC 4364's Section 3 explains that each PE has the same capability. Each PE "maintains a number of separate forwarding tables. One of the forwarding tables is the 'default forwarding table'. The others are 'VPN Routing and Forwarding tables', or 'VRFs'." *Id*., 9. Each attachment circuit between PE/CEs is associated, "by configuration," with one or more VRFs. *Id*. Whenever a new attachment circuit between the PE and a new CE is started, a new VRF is generated so that the PE is configured for the one or more VRFs.

396. Section 3 of RFC 4364 goes on to explain that a VRF on a Provider Edge (PE) router contains the routes available to a particular set of customer sites. *Id.* Additionally, Section 4, entitled "VPN Route Distribution via BGP," describes the mechanism that makes the routes within each VRF "unique" across the service provider's network, even if different customers use the same private IP

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address space. It explains how a Route Distinguisher (RD) is used to create globally unique VPN-IPv4 addresses, explaining "[i]f several VPNs use the same IPv4 address prefix, the PEs translate these into unique VPN-IPv4 address prefixes. This ensures that if the same address is used in several different VPNs, it is possible for BGP to carry several completely different routes to that address, one for each VPN." *Id*., 13.

397. Moreover, Ravindran explains that in some instances, the above-mentioned VPGs can be implemented by a CON that is configured to "map existing transport virtualization constructs, such as VPN Routing and Forwarding Table (VRF), virtual router (VR), and/or Virtual Private Local Area Network Service (VPLS) constructs, which may be used in current networks or technologies." Ex. 1016, [0070].

398. Therefore, a POSITA would have understood that RFC 4364 discloses generating at least one independently unique virtual routing table by using VRF.

5. [1.E] virtually separating at least one private data stream intended for said at least one private user device from said plurality of data streams using said at least one independently unique virtual routing table to create at least one virtually separated private data stream containing Internet Protocol (IP) data packages;

399. RFC 4364, and Ravindran disclose this limitation.

400. As explained above, the '142 patent explains that the PON interface routers "can be configured with Virtual Routing and Forwarding (VRF)" and

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"Virtual Local Area Network (VLAN) tagging" to "separate and manage the distribution of voice, video and data content traffic to each of the users." Ex. 1001, 4:52-56. This allows "data traffic intended for one tenant is automatically isolated from traffic intended for other tenants." *Id*., 5:50-52.

401. Section 5 of the RFC provides a detailed description of process for virtually separating a private data stream and forwarding the same to the intended private user device. This section includes a step-by-step logic flow of how a PE router handles an IP packet received from a CE device for forwarding to another CE device associated with an intended recipient:

402. First, a PE router receives an IP packet from a CE router. Ex. 1014, 23. The PE router then "chooses a particular VRF in which to look up the packet's destination address." *Id*. This is the first step in the claimed "virtual separation."

403. Next, the PE router looks up the packet's destination IP address of the "at least one private user device" in the located VRF. Assuming a match is found, the PE learns the packet's "next hop" (i.e., the CE router destined to receive the IP packet. *Id*., 23-24. Because the packet is sent over a VPN, the PE router does not perform a lookup in the main routing table or any other customer's VRF. The routing table used to lookup the CE router and IP address is the claimed "independently unique virtual routing table."

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404. Based on the result of that VRF lookup, the PE router determines the next hop and, when the next hop requires passing the packet across the main backbone, the PE router encapsulates the packet (e.g., using an MPLS label) for transport across the provider's network to the packet's destination address. This encapsulation creates at least one virtually separated private data stream containing one or more IP data packages that is a "virtually separated private data stream" isolated from all other traffic. *Id*., 24.

405. Ravindran also discloses using the VRF to virtually separate data streams intended for different private user devices. As shown in Figure 13 (reproduced below), each VPG instance is mapped to a respective VRF instance, and the CON may receive a plurality of packets associated with each VPG instance, and they are then mapped to the appropriate VRF instance. Ex. 1016, [0071].

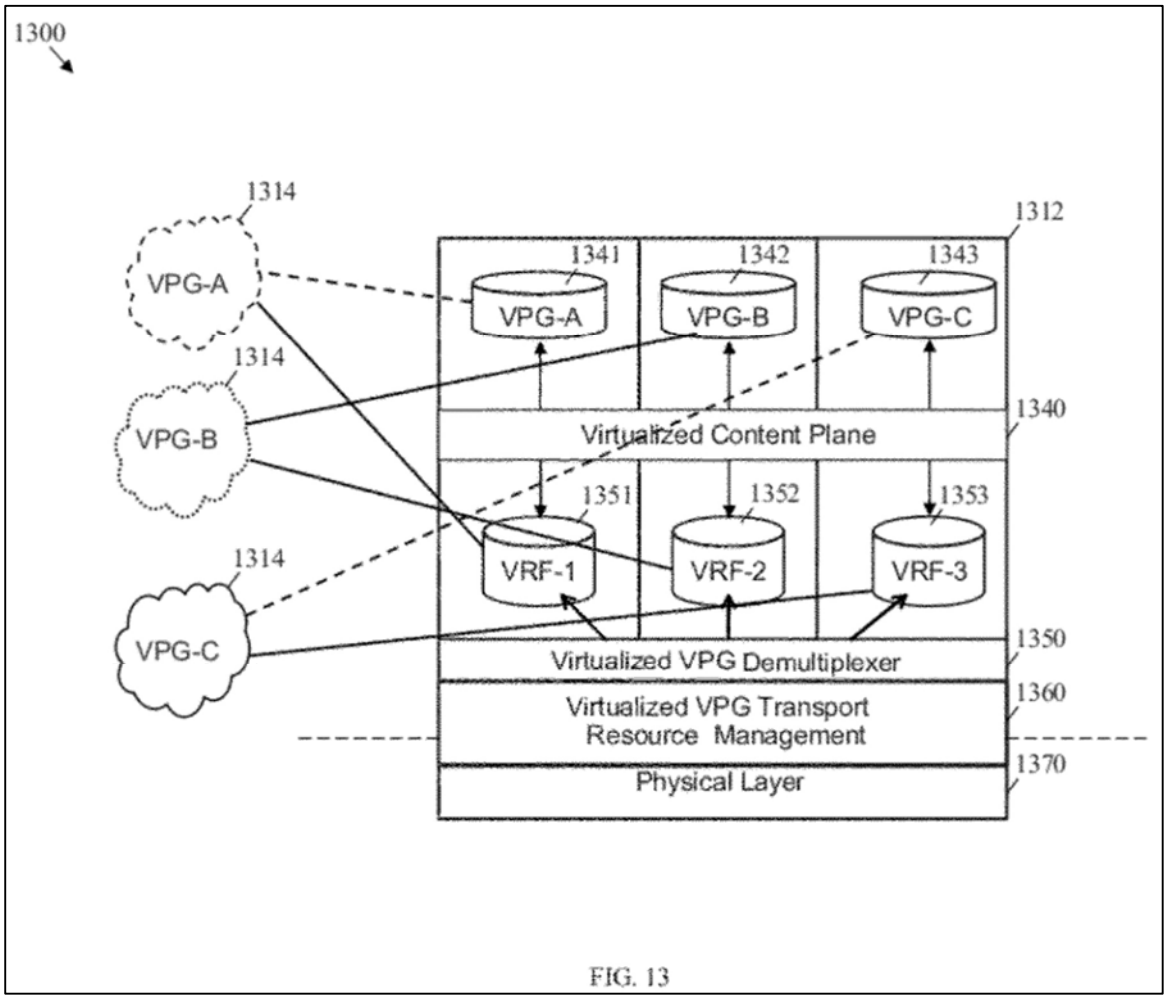

FIG. 13

6. [1.F] uniquely labelling said IP data packages contained in said at least one virtually separated private data stream using Multi-Protocol Label Switching (MPLS) to create MPLS labelled data packages;

406. The pseudo-code provided above from column 6 of the ’142 patent recites enabling MPLS. Ex. 1001, 6:38-40.

407. RFC 4364 discloses [1.F]. As discussed in [1.E], above, RFC 4364 describes the creation of MPLS labelled data packages for transport across a network for virtual separation. Ex. 1014, 3 (“Each route within a VPN is assigned a Multiprotocol Label Switching (MPLS) [MPLS-ARCH, MPLS-BGP, MPLS-

ENCAPS] label; when BGP distributes a VPN route, it also distributes an MPLS label for that route."). Specifically, RFC 4364 describes the use of a "label stack" including a VPN Route Label (inner label) and an IGP Label (outer label). The inner label identifies the specific route within the destination PE router's VRF. RFC 4364 teaches that "before a customer data packet travels across the Service Provider's backbone, it is encapsulated with the MPLS label that corresponds, in the customer's VPN, to the route that is the best match to the packet's destination address. This MPLS packet is further encapsulated (e.g., with another MPLS label or with an IP or Generic Routing Encapsulation (GRE) tunnel header [MPLS-in-IP-GRE]) so that it gets tunneled across the backbone to the proper PE router. Ex. 1014, 24. Thus, the backbone core routers do not need to know the VPN routes.

408. The IGP label (which RFC 4364 names the "IGP Next Hop") is used to forward the packet across the service provider's core network from the ingress PE to the egress PE. This label is determined by the provider's internal routing protocol (such as Open Shortest Path First (OSPF)) and is swapped at each hop until a PE determines that the next hop is a CE. *Id*., 25, 28. By labeling the IP data packages using an MPLS label, the IP data packages are ensured to remain in at least one virtually separated private data stream that is separated from other data streams. Therefore, a POSITA would have understood that RFC 4364 discloses [1.F].

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7. [1.G] sending said plurality of data streams, including said at least one virtually separated private data stream comprising said MPLS labelled data packages, to said secondary PON interface router;

409. Although the ’142 patent does not explicitly discuss sending data streams to a secondary PON interface router, a POSITA would have understood that the action of sending said plurality of data streams, including said at least one virtually separated private data stream comprising said MPLS labelled data packages, to said secondary PON interface router is the culmination of the process described in Section 5, "Forwarding" of RFC 4364. Section 5 describes the fundamental data plane logic of what to do with a packet once it arrives at a PE.

410. RFC 4364 discloses this limitation for sending MPLS labelled data packages across an IP backbone between network routers. As discussed in Section 5 of RFC 4364, a PE router receives an IP packet from a CE device. Ex. 1014, 23. The PE then identifies a relevant VRF table and looks-up a forwarding address for the IP packet in the VRF associated with the input interface. *Id*., 24. This lookup determines the next-hop router (the next P-router or the egress PE) and the MPLS VPN label to use. *Id*. The PE router then encapsulates the packet with the appropriate MPLS labels, as discussed above and as detailed in Section 7 of RFC 4364. *Id*., 27.

411. Finally, it sends (or “tunnels”) the resulting MPLS packet with the included IP packet to the next-hop router (e.g., a second PE router, which embodies

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the secondary PON interface router) via the appropriate physical interface as a part of the virtually separated private data stream of the plurality of data streams. *Id.,* 24.

412. As discussed above, a POSITA would have understood that RFC 4364's discussion of tunneling MPLS-labeled data packages across an IP network would have been used with a PON, such as the GPON discussed in G.984.1 and G.984.3, so that the PEs discussed in RFC 4364 would have been embodied as "PON interface routers" as recited in the claims that interface between a PON (as disclosed in G.984.1-3) and a network such as the IP backbone discussed in RFC 4364.

413. Ravindran also discusses sending data streams from a primary network interface router to a secondary network interface router. "Outgoing traffic" from a router is mapped to a VRF/VPG instance, and "content routers 1312 may be configured to add policies to handle different content requests/responses differently. The content plane interaction between any two content routers may be mapped to their corresponding transport layer virtualization, so that the traffic for a VPG instance may traverse the correct instance in the transport plane." Ex. 1016, [0072]. So content from one content router is transferred to a second content router along a route established for a particular VRF/VPG instance.

8. [1.H] receiving said plurality of data streams including said at least one virtually separated private data stream at said secondary PON interface router;

414. *See* limitation [5.A].

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415. The ’142 patent describes the functionality of the secondary PON interface router (and the corresponding OLT) with respect to figure 4. The ’142 patent explains that Figure 4 (reproduced below) “represents the Passive Optical Network infrastructure which is an optical distribution network used to convey the photonic broadcast stream feeds that contain the encrypted data packets such as VLAN-tagged ethernet frames.” Ex. 1001, 6:58-62. Those data packets are part of telecommunications service traffic that includes Internet, public switched telephone networks, and broadcast/cable television. *Id*., 4:23-26.

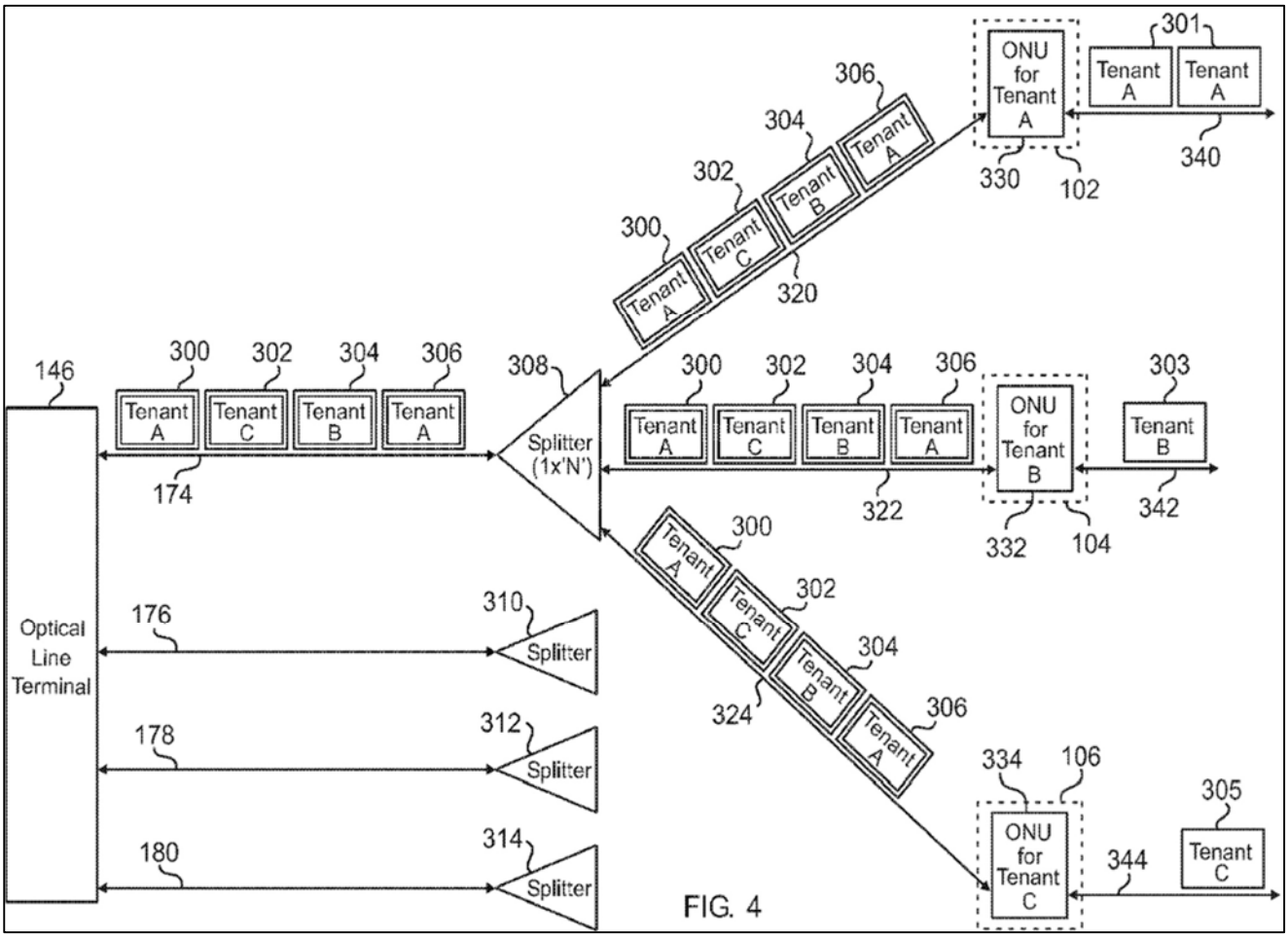

FIG. 4

416. As discussed above, RFC 4364 describes a first PE router forwards/tunnels an IP packet within a MPLS packet to "the next hop," such as a second PE router "where the VPN label will be examined. *Id*., 25. The treatment of the packet at the second PE router depends on the VPN route label of the received packet in the at least one virtually separated private data stream of the received plurality of data streams. *Id*. The second PE "may only be able to determine that the packet's destination address needs to be looked up in a particular VRF before being forwarded to a CE device." *Id*. A POSITA would have understood that a second PE can only determine a packet's destination address once that second PE *receives* the IP packet.

417. The discussion of Ravindran in [1.G] also indicates that a content router (either the primary or secondary content router) receives data streams for a plurality of virtually separated VPG instances. Ex. 1016, [0070]-[0071].

9. [1.I] converting said MPLS labelled data packages contained within said at least one virtually separated private data stream back to said IP data packages;

418. The '142 patent does not discuss converting MPLS labelled data packages to an IP data package. However, the '142 patent explains that uniquely VLAN-tagging data streams allows "overlapping IP address[es] on a single PON infrastructure" (Ex. 1001, 5:65-67), so that IP data packages can be delivered to their intended destination.

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419. RFC 4364 discloses this limitation. Section 5 of RFC 4364 explains how a PE (e.g., the second PE) forwards information to a recipient CE. Ex. 1014, 25. Once the MPLS labelled data package arrives at the second PE, the PE "determines the attachment circuit over which the packet should be transmitted (to a CE device), as well as the proper data link layer header for that interface." *Id*.

420. As RFC 4364 explains, "if the packet was an unlabeled IP packet when it arrived at its ingress PE, it will again be an unlabeled packet when it leaves its egress PE." *Id*., 25. To recreate the "unlabeled" IP data package, the PE "pops" the label stack (i.e., removes the MPLS label) of the MPLS labelled data packages contained within said at least one virtually separated private data stream and sends it to its destination CE, as determined within the VRF table identified using the MPLS label of the data package. *Id*., 17, 25.

10. [1.J] forwarding said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages from said secondary PON interface router to a PON optical line terminal (OLT);

421. As discussed above, the '142 patent explains that data streams are provided from the PON interface router to the OLT to forward broadcast stream feeds to various tenant spaces. Ex. 1001, 6:58-64.

422. G.984.1 discloses this limitation.

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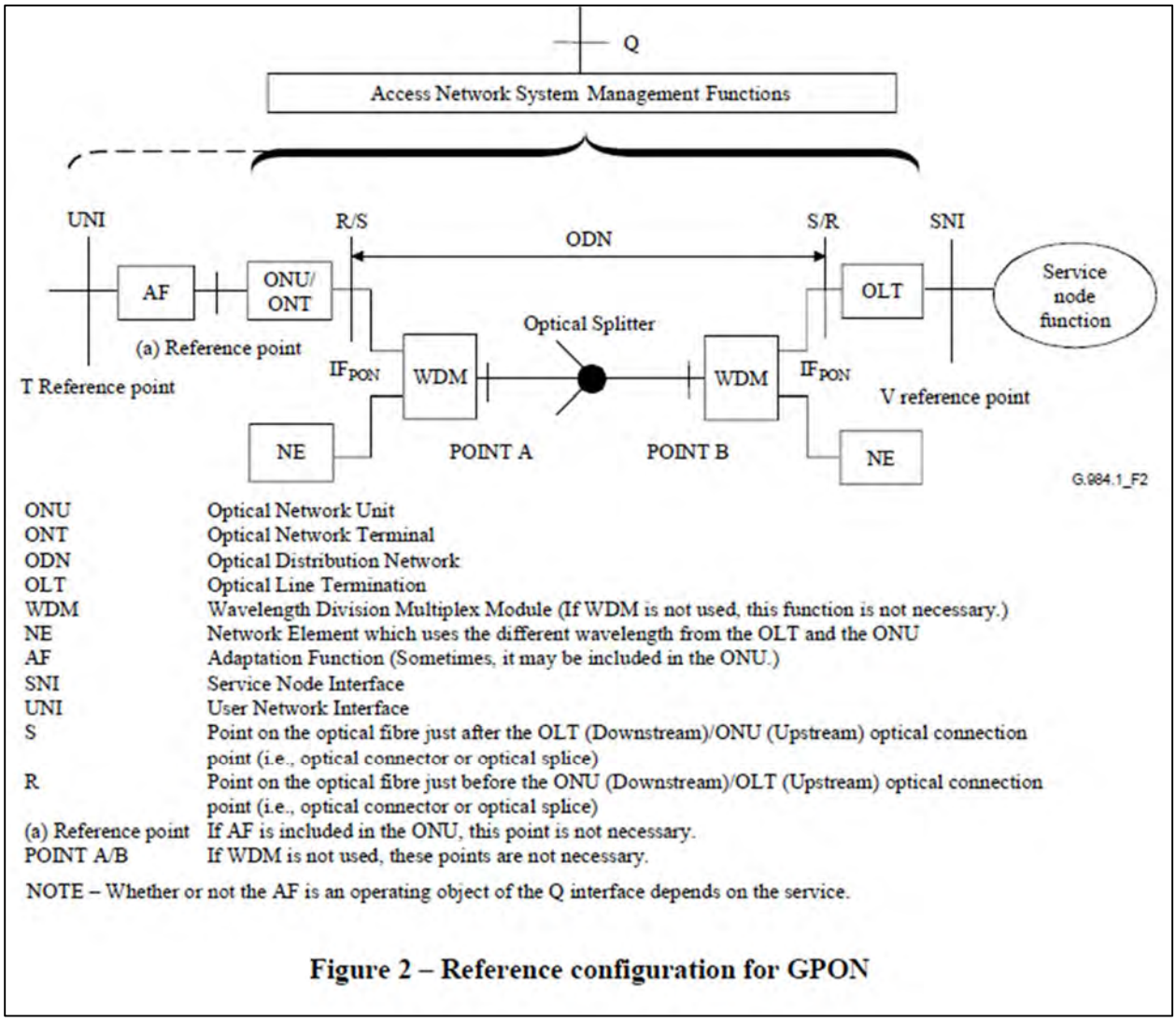
423. As shown in Figure 2 from G.984.1, for example, data streams are forwarded from the service node function to an OLT before the data streams are provided to the end users (e.g., at an ONU). Ex. 1011, 12.



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

424. Because the OLT is connected to the IP backbone and the plurality of customer locations (the ONUs), the OLT is connected to a provider edge (PE) of the IP backbone network as discussed in RFC 4364, so that the PE (e.g., the secondary PE of RFC 4364) forwards the plurality of data streams that are destined for ONUs

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connected with the OLT, including the at least one virtually separated private data stream containing said IP data packages. Ex. 1014, 24-25.

425. G.984.1 confirms that, in a PON, a PON interface router forwards said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to a PON optical line terminal (OLT). As shown in Figure 2 from G.984.1, for example, data streams are forwarded from the service node function to an OLT before the data streams are provided to the end users (at an ONU). Ex. 1011, 12.

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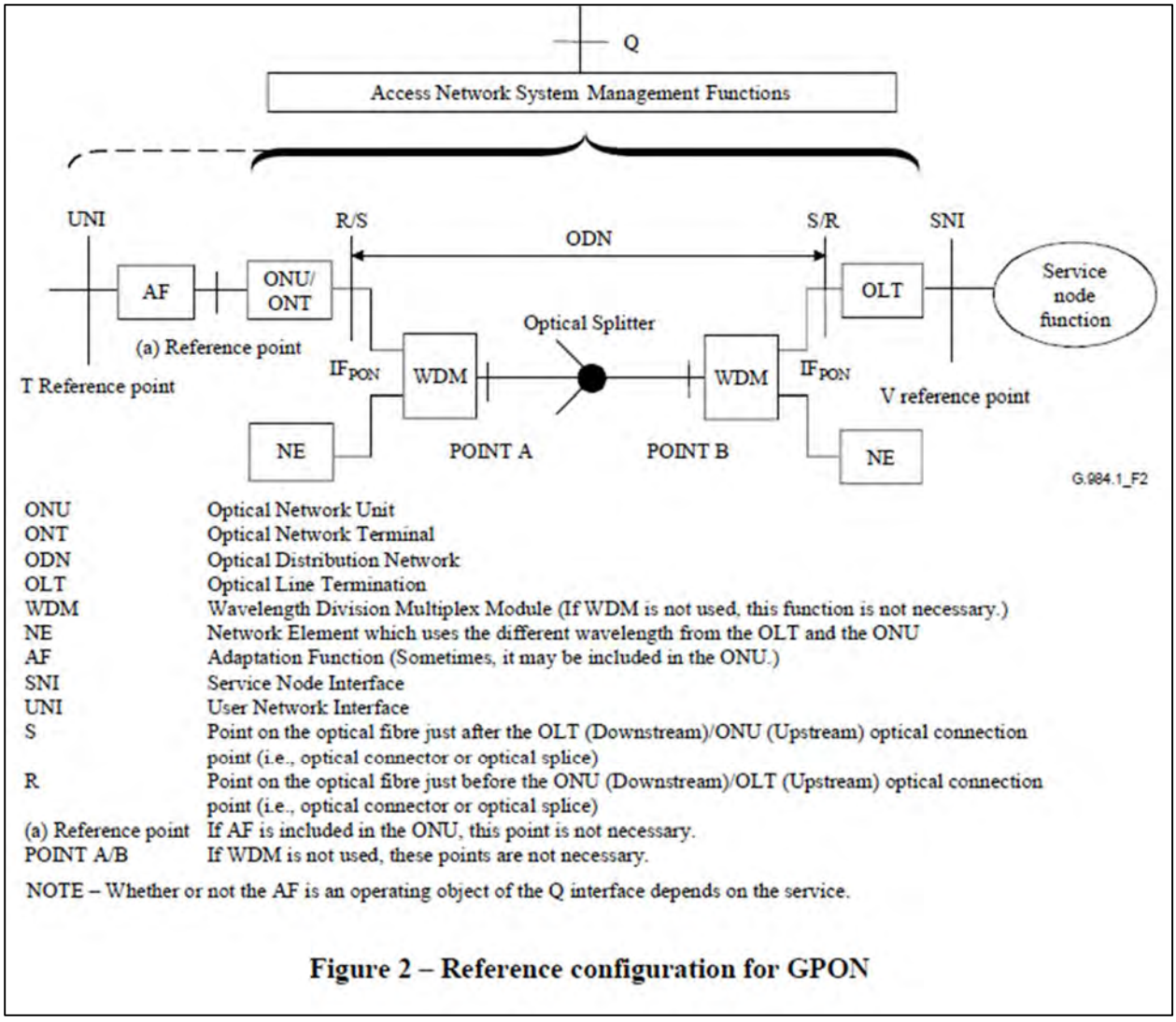

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(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

11. [1.K] aggregating within said PON OLT said plurality of data streams and said at least one virtually separated private data stream into a common data feed;

426. *See* limitation [5.B].

427. As shown in Figure 4 of the ’142 patent (shown above), data streams for multiple tenants (specifically, Tenant A, Tenant B, and Tenant C are all included in a common data feed. Ex. 1001, 6:58-67. As the ’142 patent explains “the OLT can broadcast the combined encrypted VLAN-tagged ethernet frames 300, 302, 304,

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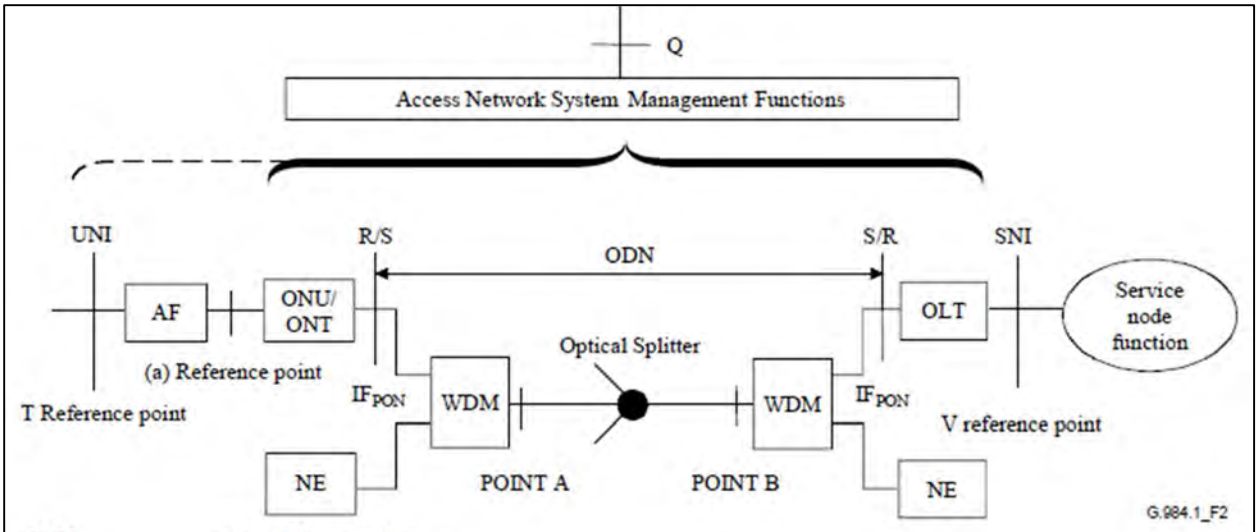
306 over the distribution feeds 174, 176, 178, 180 to a number of splitters 308, 310, 312, 314." *Id*.

428. G.984.1 discloses this limitation. As shown in Figure 2 of G.984.1, shown below, signals are distributed to multiple end users using an optical splitter – a device that does not have any inherent ability to segregate different signals to different end users based on their intended end users. Instead, signals for any end user are included in the same signal, and the signal is split using the optical splitter so that all end users receive all data signals in a single data stream. *See* Ex. 1011, 12.



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WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
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(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

429. G.984.3 provides more detail about how data for different ONUs can be aggregated onto a common data feed, using time division multiplexing and GEM Frame-IDs that each receiving ONU use to determine which data frames are relevant for the receiving ONU. Ex. 1013, 17.

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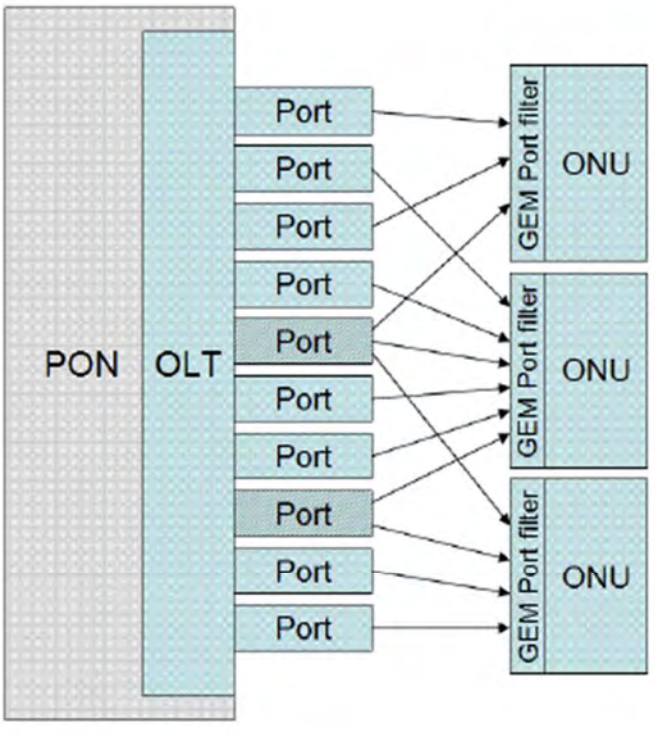

Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

12. [1.L] distributing said common data feed to said plurality of ONUs;

430. *See* limitation [5.C].

431. As discussed above, G.984.3 describes that the common data feed is distributed to a plurality of ONUs using the optical splitter that directs identical optical signals along optical lines connected with each of the ONUs. Ex. 1013, 21.

432. For example. G.984.1 states that there are a plurality of ONUs that receive a common data feed from the OLT. Ex. 1011, 12.

433. GPON systems are characterized, in general, by an optical line termination (OLT) system and an optical network unit (ONU) or optical network

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termination (ONT) with a passive optical distribution network (ODN) interconnecting them. There is, in general, a one-to-many relationship between the OLT and the ONUs.

434. This general architecture is depicted throughout G.984.1.

I.2 Typical system architectures

Figure I.1 shows a generic GPON system. This is developed more specifically in Figures I.2 to I.7.

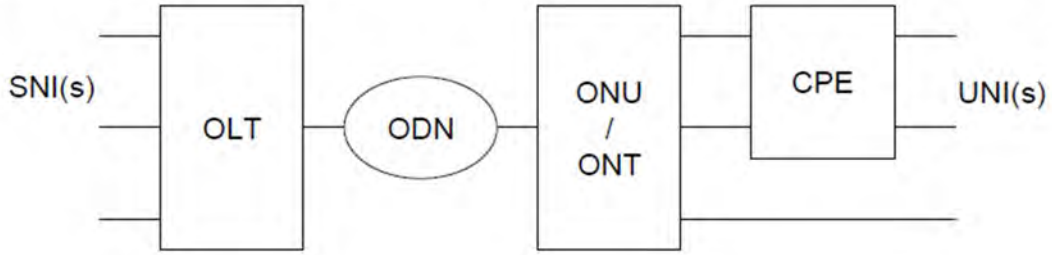

Figure I.1 – Generic GPON system

Ex. 1011, 20.

435. G.984.3 discloses a one-to-many configuration for connecting an OLT to a plurality of ONUs at least in Fig. 5-1.

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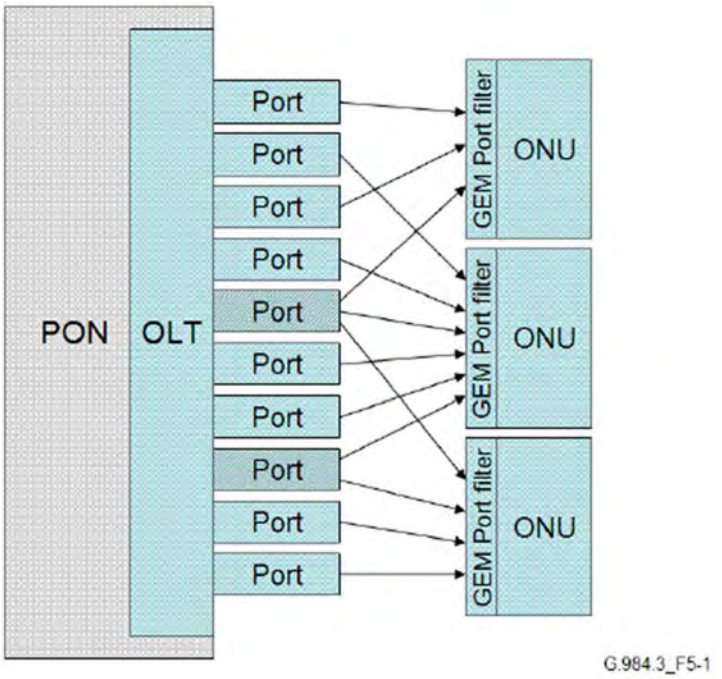


Figure 5-1 – Downstream multiplexing (shaded GEM port indicates multicast)

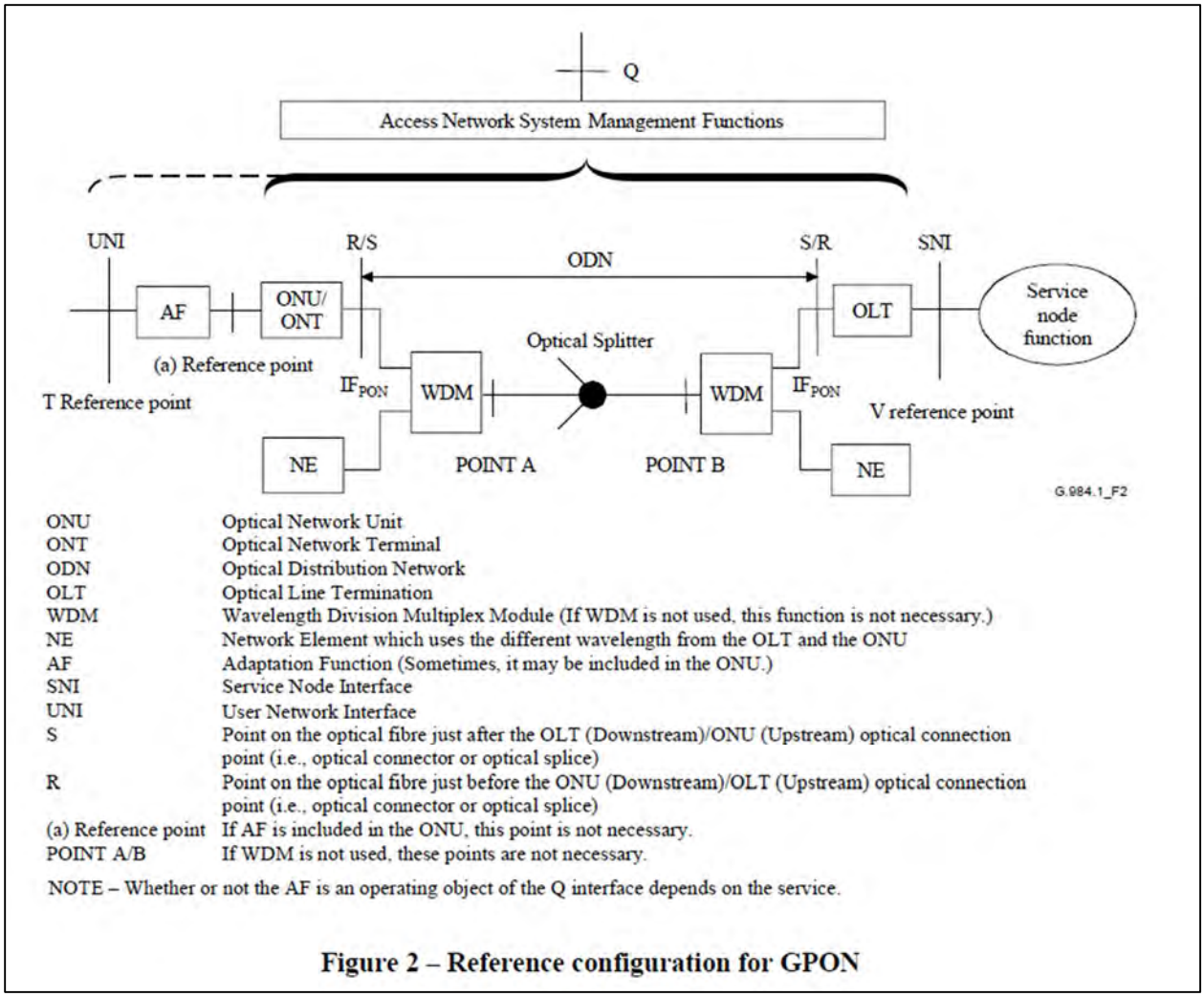
Ex. 1013, 17.

13. [1.M]/[1.N] wherein said distributing comprises: replicating said common data feed using at least one optical splitter connected to said plurality of ONUs;

436. *See* limitations [5.D]/[5.E].

437. As discussed above, G.984.1 and G.984.3 discloses an optical splitter that replicates the common data feed and is connected to said plurality of ONUs. *Id*.

438. Figure 2 of G.984.1 depicts the optical splitter.



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ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
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SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

439. The splitter and the allowable split ratio is further discussed within G.984.1. *Id*., 12-13. For example, it teaches that "split ratios of up to 1:64 are realistic for the physical layer, given current technology." *Id*. Here, the ratio is the number of ONU's (64) that can be connected with a single (1) OLT port. The "split" in "split ratio" refers to the use of optical splitters, that replicate the data feed to all of the ONUs connected with the splitter. *Id*. ("a larger split ratio implies greater optical splitting").

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440. G.984.3 confirms the use of optical splitters to distribute signals from the OLT to a plurality of ONUs. Ex.1013, 22.

14. [1.O] delivering said common data feed to said plurality of ONUs;

441. *See* limitation [5.F].

442. As discussed above, the optical splitter of G.984.3 is connected with optical lines connected each respective ONU, so that the common data feed is replicated and delivered to each of the plurality of ONUs. *Id*.

443. Figure 2 of G.984.1 depicts the optical distribution whereby the common data feed is delivered to the plurality of ONUs.

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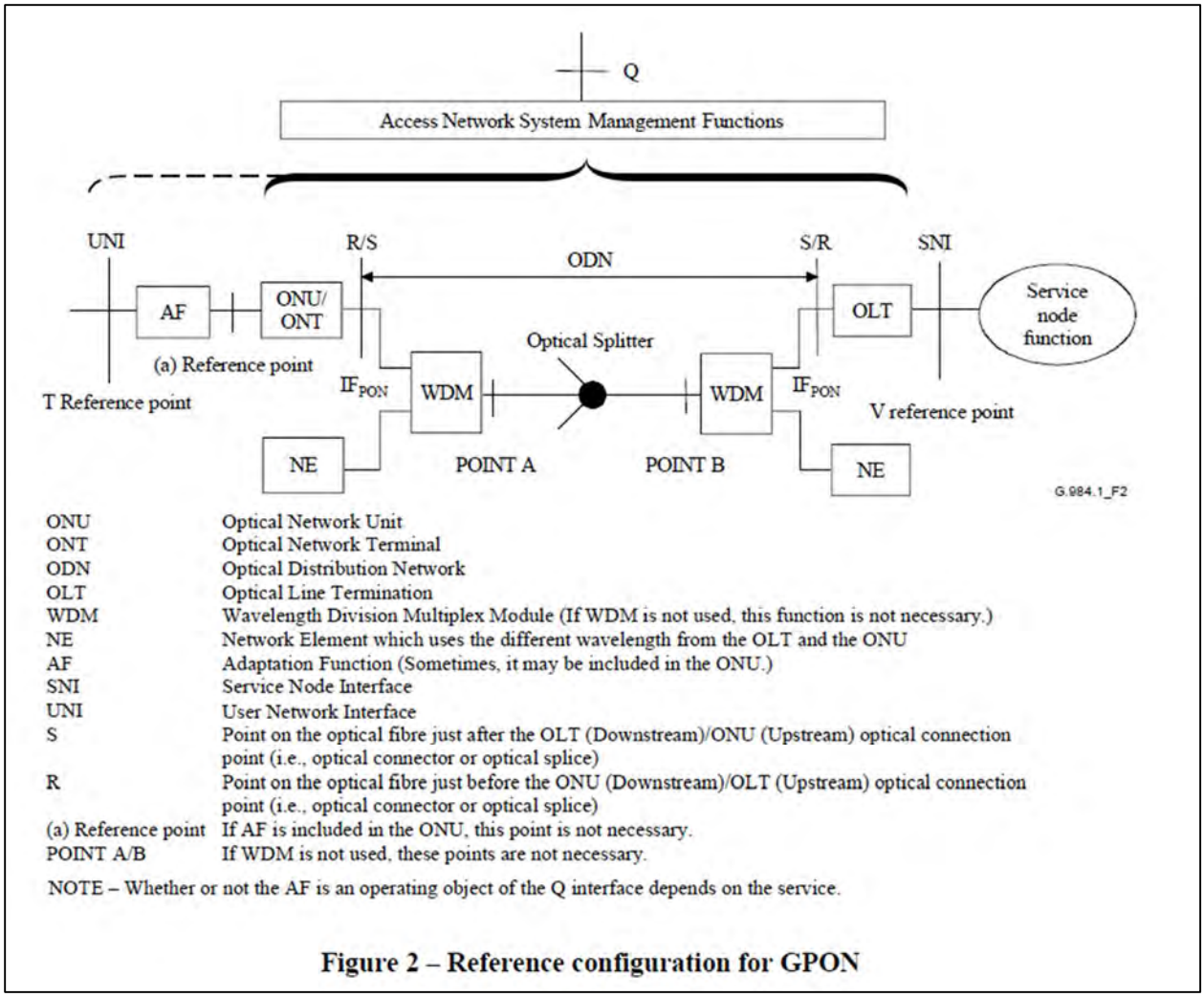

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POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

Ex. 1011, 12.

444. As discussed, G.984.1 contemplates that at least 64 ONUs can be connected to a single OLT port. *Id*.

15. [1.P] extracting within said at least one of said plurality of ONUs, said at least one virtually separated private data stream including said IP data packages from said common data feed;

445. *See* limitation [5.G].

446. G.984.1 and G.984.3 discloses limitation [5.G]. GPON, as described in G.984.1 and G.984.3, utilizes the GPON Encapsulation Method (GEM), which is a

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data transport scheme to send data from the OLT to ONUs. Ex. 1013, 15-16. According to G.984.3 "GEM provides a connection-oriented, variable-length framing mechanism for transport of data services over the passive optical network (PON) and is independent of the type of the service node interface at the OLT as well as the types of UNI interfaces at the ONUs." *Id*. G.984.3 further explains that "IP packets are carried directed in the GEM frame payload." *Id.* at 128.

447. G.984.3 further explains that a given ONU only extracts the GEM frames that have been specifically addressed to that ONU despite the fact that the ONU receives the GEM frames for other ONUs that are part of the common data feed.

> In the downstream direction, the traffic multiplexing functionality is centralized. The OLT multiplexes the GEM frames onto the transmission medium using GEM Port-ID as a key to identify the GEM frames that belong to different downstream logical connections. Each ONU filters the downstream GEM frames based on their GEM Port-IDs and processes only the GEM frames that belong to that ONU.

Ex. 1013, 17.

448. As such, G.984.3 teaches that at least one of the ONUs extracts the virtually separated data stream that includes IP data packages from the common data feed that is received over the ODN.

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16. [1.Q] sending said at least one virtually separated private data stream including said IP data packages from said at least one of said plurality of ONUs to said at least one private user device of a plurality of user devices.

449. *See* limitation [5.H].

450. The '142 patent explains that once ONU-specific data feeds are decrypted, they are "then made available 340, 342, 344 for the tenant's IP/ethernet end-user equipment. Ex. 1001, 7:27-29.

451. As discussed above in [5.G], G.984.1 and G.984.3 discloses that a given ONU extracts only the IP packages from a GEM frame where the GEM port ID matches the ONU. The purpose of extracting that IP package is to send the IP package (in the at least one virtually separated private data stream) from the at least on ONU to the at least one private user device that is connected to that ONU of the plurality of user devices, while discarding any data that is intended for user devices connected to different ONUs. The purpose of an access network, such as the one described by G.984.1-3, is to provide access to user devices to a wider network, such as the internet or other IP networks. G.984.1 teaches a "User Network Interface" that exists downstream of an ONU, such as gigabit ethernet. Ex. 1011, 20. This is depicted in Fig. I.1.

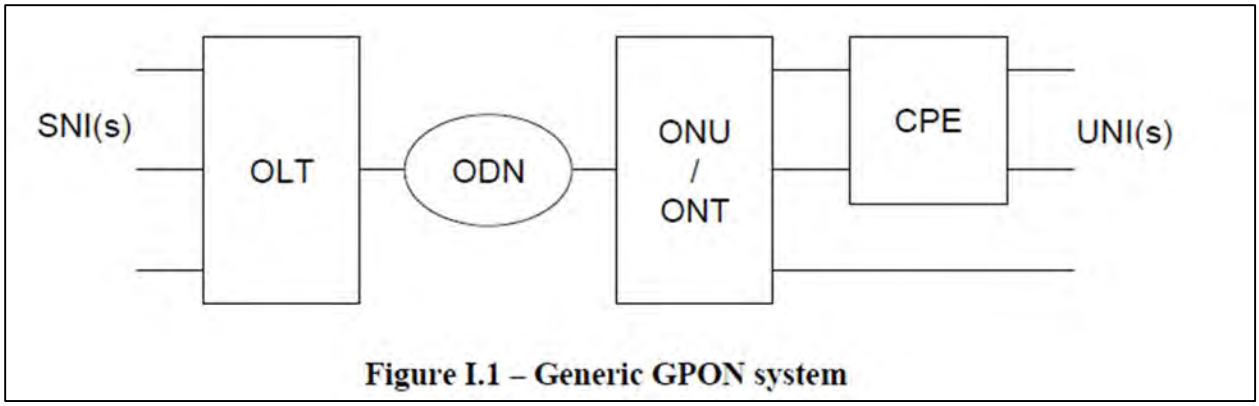

Figure I.1 – Generic GPON system

Id., 20.

452. G.984.1 further describes that "[i]n the ONT, Ethernet frames as defined in [b-IEEE 802.3] are extracted from the TC layer. In some ONTs, the Ethernet layer is quite abbreviated and little processing is done on the frames from their reception on the GPON interface to their transmission on the UNI." *Id*. G.984.1 further notes that "[i]n some ONTs, some sort of VLAN processing is done, as defined in the IEEE 802.1-series of standards." G.984.1 further explains that this can be to identify the specific user by a VLAN-ID.

> This typically involves adding tag(s) in the upstream, and removing tag(s) in the downstream, for the purpose of identifying each user/service packet via their VLAN-ID. However, this is not necessary in all cases, since the PON itself has the GEM port-ID mechanism for such identification.

Id.

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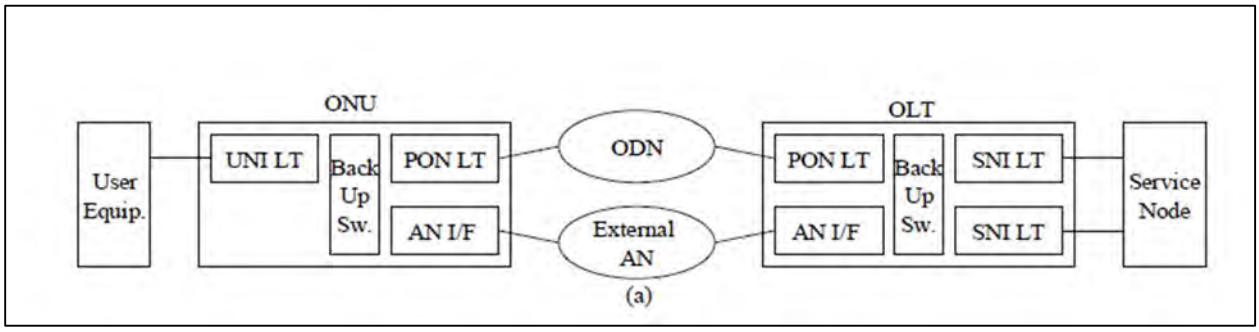
453. G.984.1 further confirms that user equipment is downstream of an ONU.



Ex. 1011, 34.

H. Claim 2 – The method of claim 1, wherein said at least one of said plurality of ONUs provides services to at least one private user of plurality of users

454. *See* Claim 6.

I. Claim 3 – The method of claim 1, wherein said secondary PON interface router is serially connected to at least one additional PON interface router that is serially connected to said PON OLT, wherein said least one additional PON interface router delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.

455. Although this limitation is not discussed in detail in the '142 patent, this is a typical configuration of data networks generally, as discussed in RFC 4364, and is a typical configuration of PON networks specifically, as disclosed in G.984.1 and G.984.3.

456. RFC 4364 discloses claim 3. RFC 4364 explains that "route reflectors" are used as interim routers between PEs to create a serial route of a plurality of routers to provide information from a first PE to an end user, through a series of

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routers, the OLT, and ultimately to an end user. Ex. 1014, 20, 23. RFC 4364 explains that "tunneling" between end points "DOES NOT require that the tunnels be point-to-point; multipoint-to-point can be used." *Id*., 26. Various "P routers" can be used as interim routers to determine a tunnel from edges. Therefore, the "secondary" PE router can be connected directly with the primary PE router, or there can be one or more interim routers that function to forward the at least one virtually separated private data stream containing said IP data package. In such a case, any of the interim routers can be a "secondary" router as the term is used in claim 3, which is serially connected to at least one additional router that is serially connected to said OLT (when the network is a PON). Therefore, RFC 4364 explains that the configuration of claim 3, with an "additional router" is usable in networks that provides VRF-based VPN services to end users..

457. Moreover, G.984.1 confirms that this configuration is standard for PON networks. As shown in G.984.1's Figure 2, below, an OLT is connected to a service node function (such as a PON interface router) that forms a provider edge node of the PON. Ex. 1011, 12.

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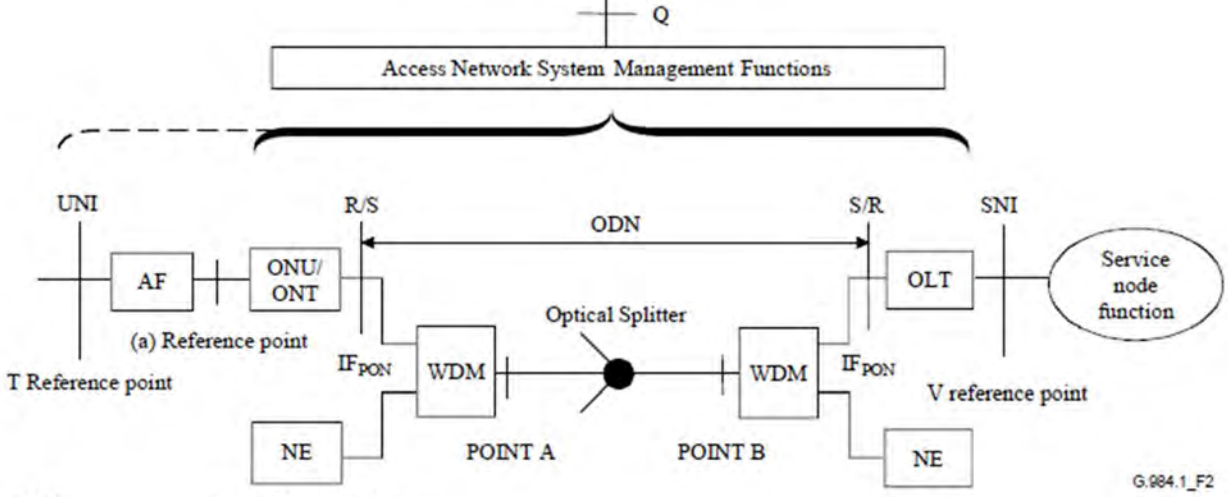

ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
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NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 2 – Reference configuration for GPON

J. Claim 4 – The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT

458. *See* Claim 7.

459. The ’142 patent states that “an aggregation switch [is] referred to as an Optical Line Terminal (OLT),” and is depicted in Fig. 2 as element “146.” Ex. 1001, 4:34-38.

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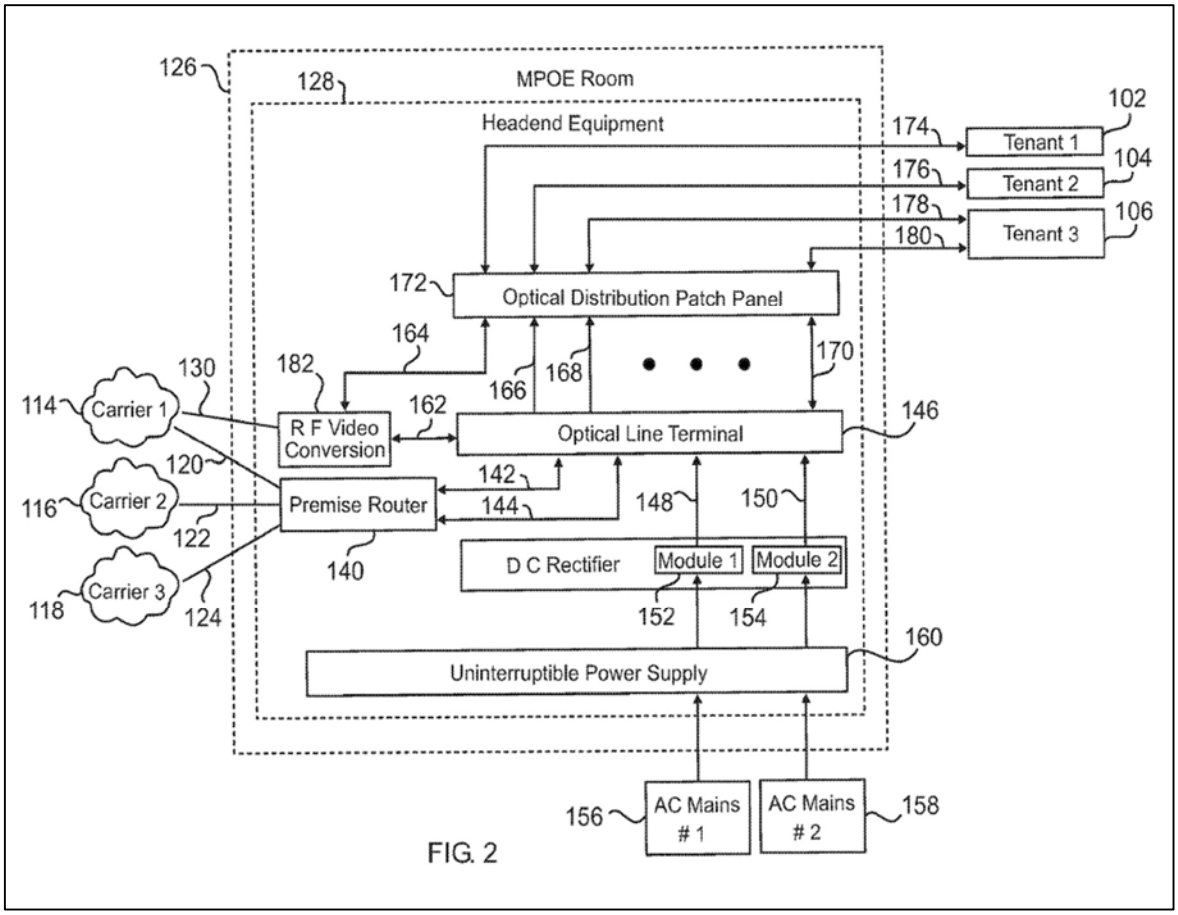

FIG. 2

460. G.984.1 discloses this claim, by explaining that an OLT includes an aggregation switch and a PON Line Terminal (PON LT) in serial connection with the aggregation switch. Ex. 1011, 14. G.984.1 discloses switches located between a service node interface and PON Line Termination (PON LT), to be connected in series with the PON Line Termination. *Id*. The switch delivers the plurality of data streams from the service node (which includes the virtually separate private data stream containing the IP data packages, received from the service node, as discussed above).

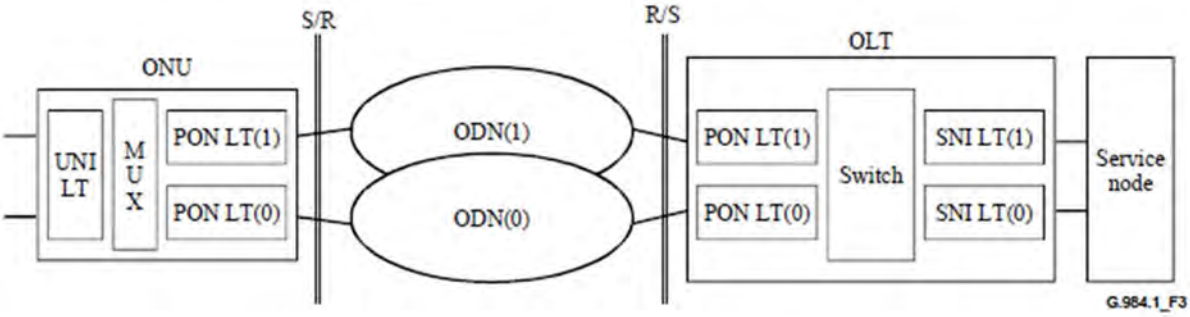

Figure 3a – Duplex system model

461. While Fig. 3a depicts the PON LT, the switch, and the SNI LT as part of the "OLT," a POSITA would understand that the PON LT is functioning as the OLT of Claim 7. This is further shown by Fig. 2 of G.984.1, which depicts the SNI as outside of the OLT.

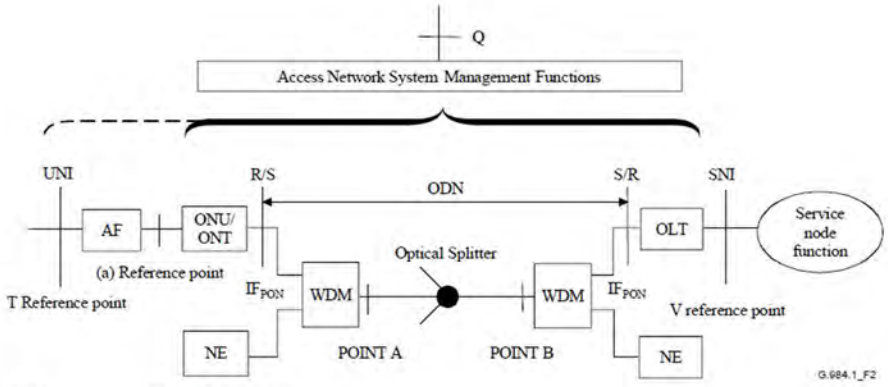

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Figure 2 – Reference configuration for GPON

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462. Regardless, the ’142 patent contemplates that the aggregation switch and the OLT could be contained within the same physical device. And Fig. 3a shows that a switch that is serially connected between the device that is performing the digital to optical conversion, the PON LT, and the broader network, which would include a PON interface router. *See* Claim [5.A].

XV. Ground 4: The combination of G.984.1 in view G.984.3, RFC 4364, Ravindran, and BCM56685 renders claims 4 and 7 obvious.

463. As discussed in Ground 3, claims 1-9 are obvious over the combination of G.984.1, G.984.3, RFC 4364, and Ravindran. BCM56685 provides additional disclosure that is relevant to dependent claims 4 and 7, each of which recite an “aggregation switch” that “delivers said plurality of data streams including said at least one virtually separated private data stream containing said IP data packages to said PON OLT.” BCM56685 is a published product data sheet showing that such a product already existed, and was advertised in publicly available data sheets as having capabilities relevant for implementing a VRF over a PON. For at least those reasons discussed below, a POSITA would have been motivated to combine the teachings of BCM56685 with G.984.1, G.984.3, RFC 4364, and Ravindran, and would have had a reasonable expectation of success in doing so. Therefore, claims 4 and 7 are obvious over the combination of G.984.1, G.984.3, RFC 4364, Ravindran, and BCM56685.

A. Motivation to Combine

464. As discussed in Ground 3, a POSITA would have been motivated to combine G.984.1, G.984.3, RFC 4364, and Ravindran, and would have had a reasonable expectation of success. I believe that the combination discussed in Ground 3 is sufficient to show that all of claims 1-9 are obvious.

465. However, in addition to those reasons discussed in Ground 3 for combining G.984.1, G.984.3, RFC 4364 and Ravindran, a POSITA would have been further motivated to look at BCM56685 when implementing an aggregation switch as a part of a VRF implementation over a PON, at least because BCM56685 demonstrates that such a product was publicly advertised and available prior to the '142 patent filing date.

466. A POSITA would have been motivated to combine G.984.1, G.984.3, RFC 4364, Ravindran, and BCM56685 to use a VRF-based virtual data separation (as discussed in RFC 4364, Ravindran, and specifically for using a VRF-enabled switch chip, as discussed in BCM56685) on a CON that delivers content to end users at ONUs using as a fiber optic network such as a PON as described in G.984.1 and G.984.3.

467. BCM56685 is a published Broadcom datasheet that describes the features and benefits of an Ethernet switch chip that was available and publicly

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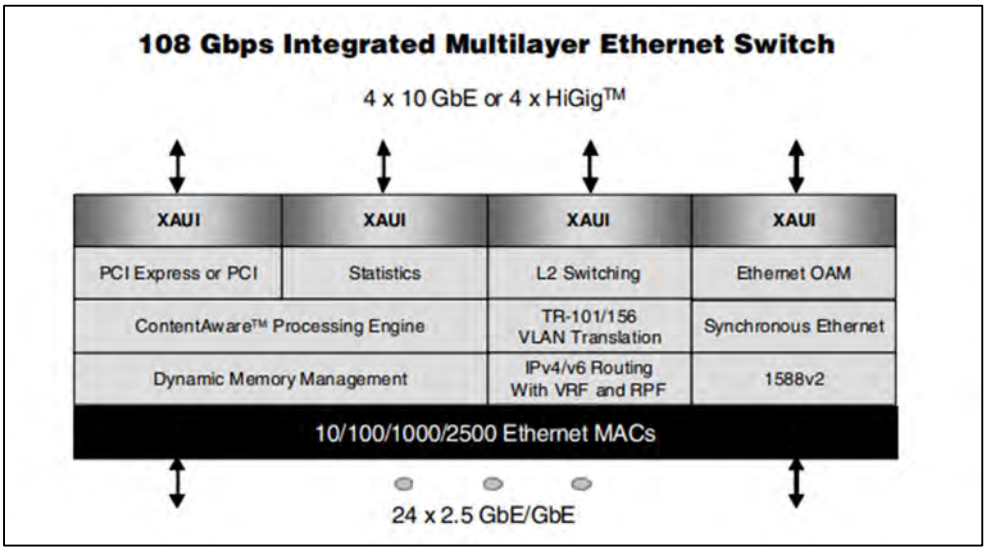
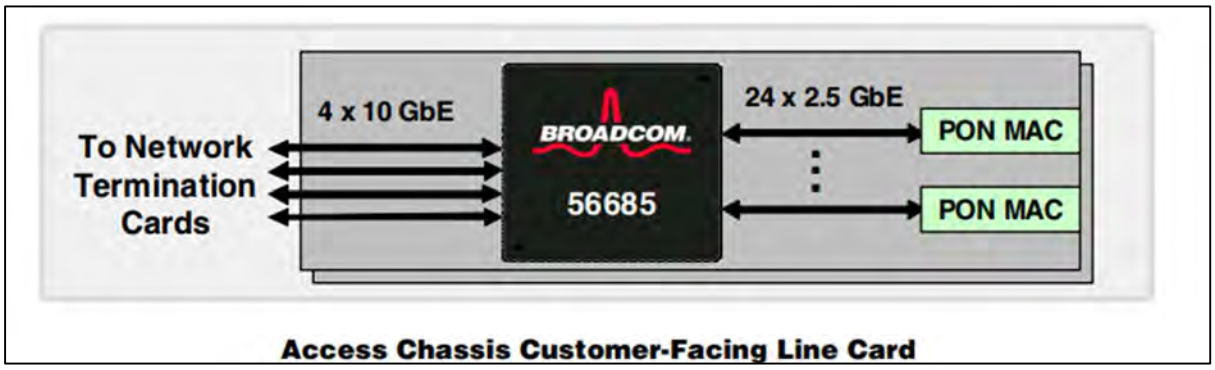
advertised prior to the time of the '142 patent filing date. The data sheet describes that the advertised chip supports "IPv4/v6 Routing with VRF and RPF."



468. The datasheet also discloses that the described chip was advertised to be deployed to facilitate the transport of data to and from a PON.



469. A POSITA reviewing this data sheet would have known that VRF separated traffic could be distributed on a PON to end users as this functionality was part of a publicly advertised and commercially available product from one of the largest semiconductor manufacturers and advertised in printed publications such as the above-mentioned BCM56685 datasheet for years prior to the priority date. A

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POSITA would have been motivated to look to both the prevalent PON standards of the time (GPON) for additional information regarding PONs and the relevant VRF documentation (RFC 4364) for additional information regarding VRF, and to commercially available products, as discussed in BCM56685, for providing VRF functionality over a PON. A POSITA would have also had a reasonable expectation of success in implementing the teachings of BCM56685 with G.984.1, G.984.3, RFC 4364, and Ravindran, at least because BCM56685 describes a commercially available product that is advertised as compatible with both PONs and VRFs.

B. Claim 7 - The method of claim 5, wherein said at least one PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said aggregation switch delivers said plurality of data streams including said at least one virtually separated private data stream comprising said IP data packages to said PON OLT.

470. The ’142 patent states that “an aggregation switch [is] referred to as an Optical Line Terminal (OLT),” and is depicted in Fig. 2 as element “146.” Ex. 1001, 4:34-38.

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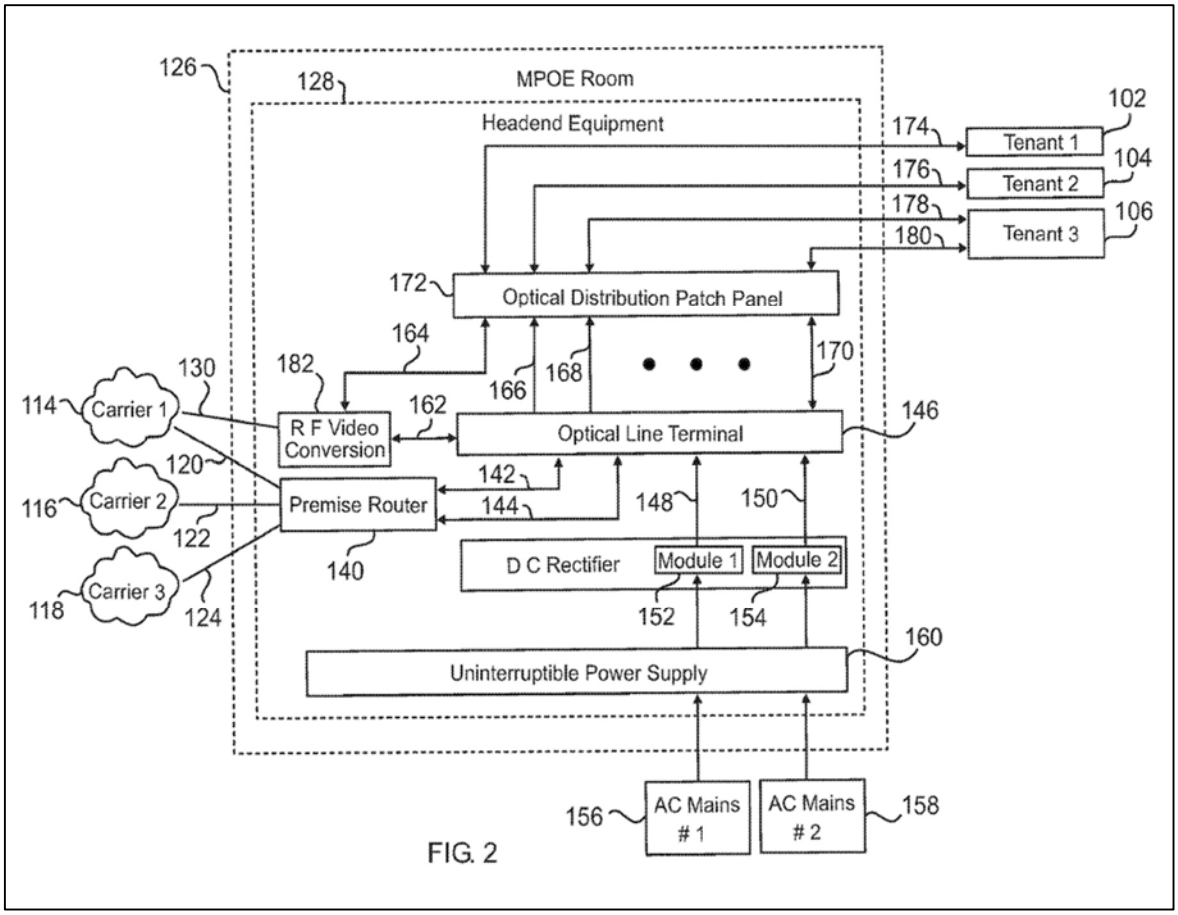

FIG. 2

471. As discussed in Ground 3, G.984.1 discloses this claim, by explaining that an OLT includes an aggregation switch and a PON Line Terminal (PON LT) in serial connection with the aggregation switch. Ex. 1011, 14. G.984.1 discloses switches located between a service node interface and PON Line Termination (PON LT), to be connected in series with the PON Line Termination. *Id*. The switch delivers the plurality of data streams from the service node (which includes the virtually separate private data stream containing the IP data packages, received from the service node, as discussed above).

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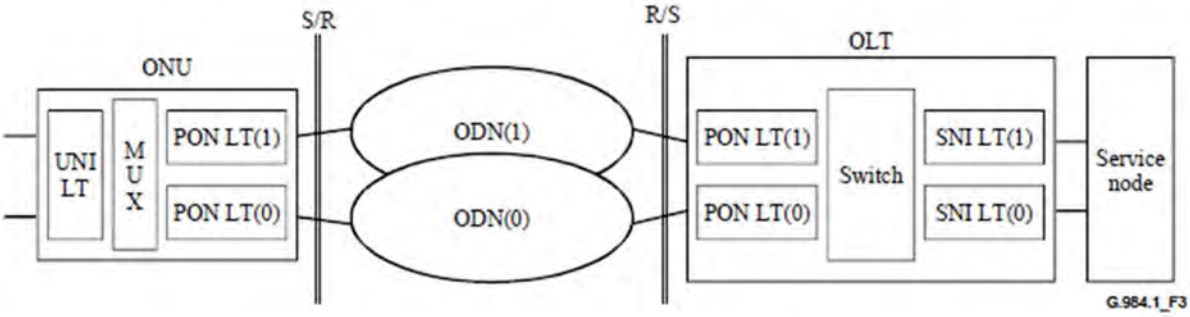

Figure 3a – Duplex system model

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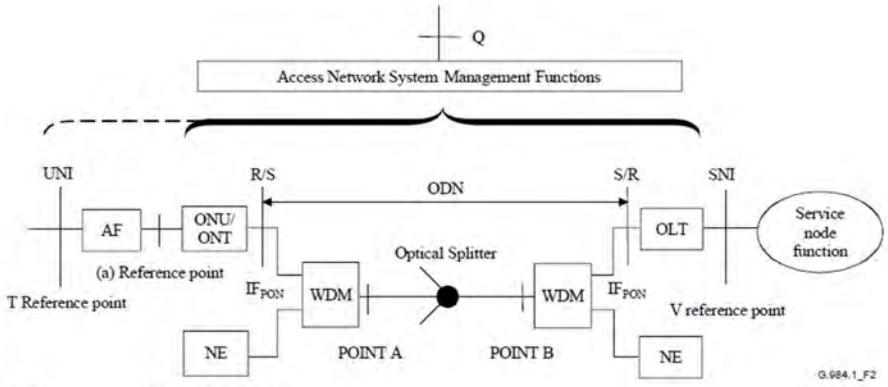

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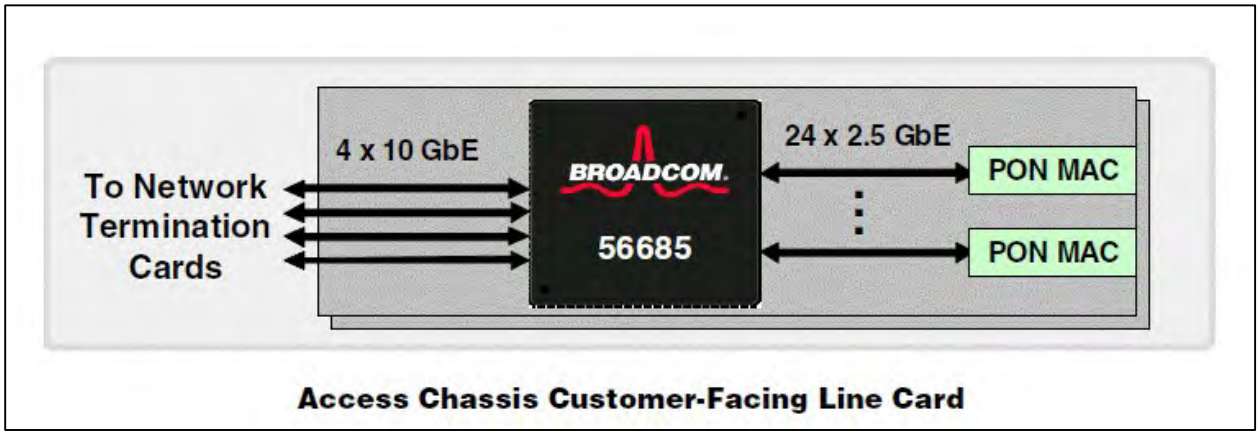
474. Additionally, BCM56685 teaches the use of an aggregation switch between the OLT and a PON interface router. BCM56685 is a publicly available product brief for a "108 Gbps Integrated Multilayer Ethernet Switch" chipset. This switch chip is advertised as being specifically designed for use with GPON. Ex. 1020 at 2 ("With its 2.5 Gbps interfaces the BCM56685 is tailored for direct interfaces to GPON ports and dense DSL line cards, minimizing total system power, board area, and solution cost."). The figures also show that it is designed to exist between network termination cards and a PON.



C. Claim 4 – The method of claim 3, wherein said at least one additional PON interface router is serially connected to an aggregation switch that is serially connected to said PON OLT, wherein said

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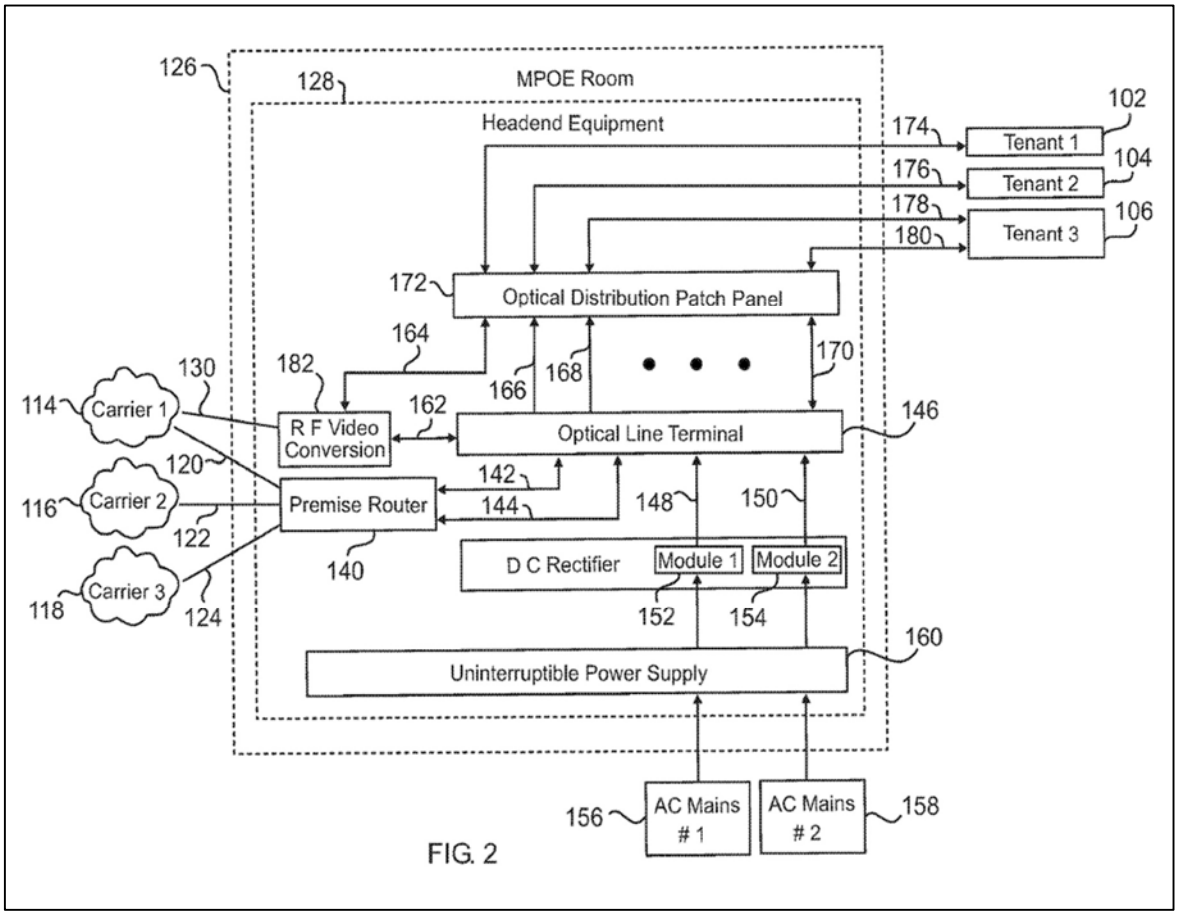

FIG. 2

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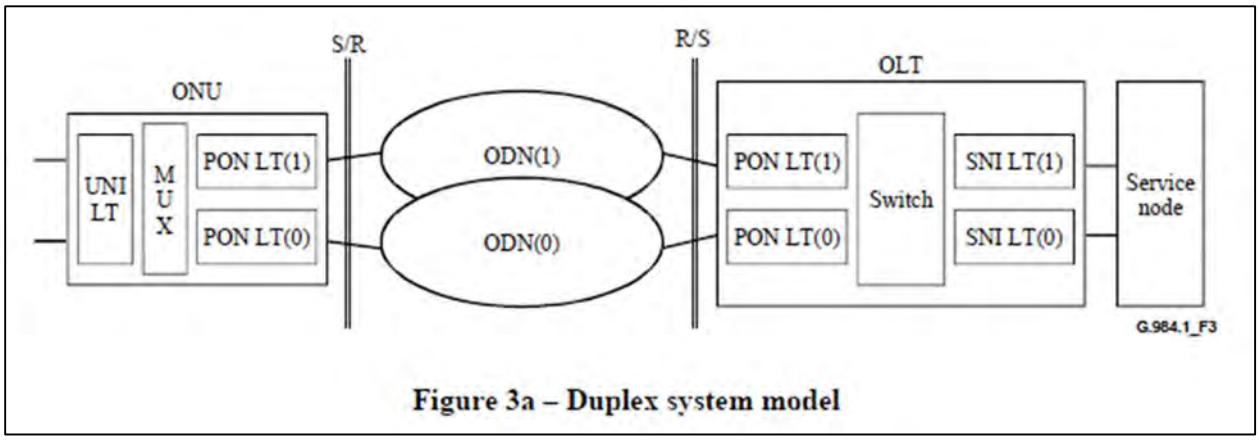

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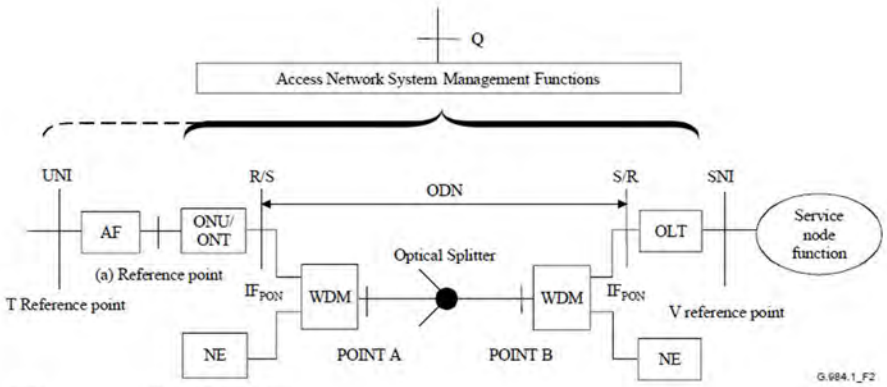

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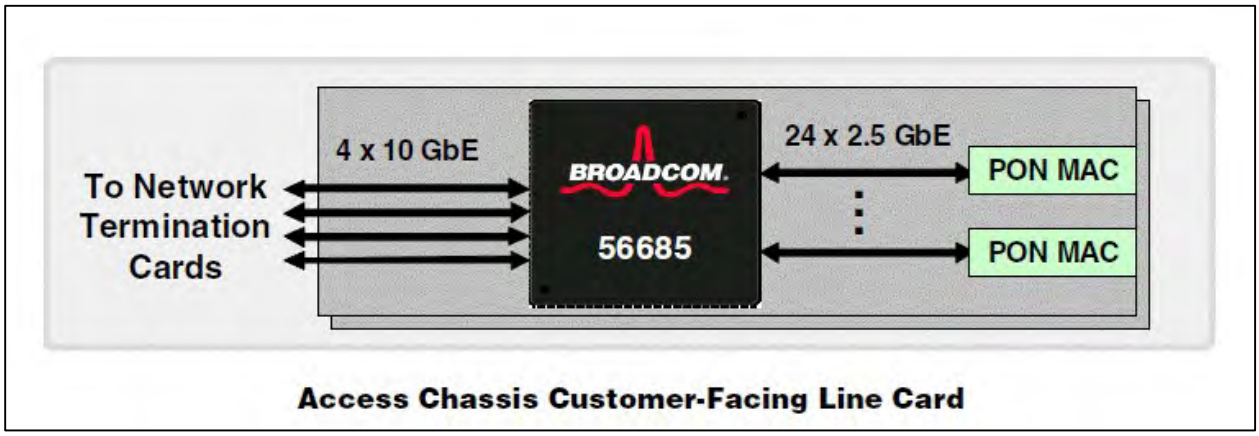
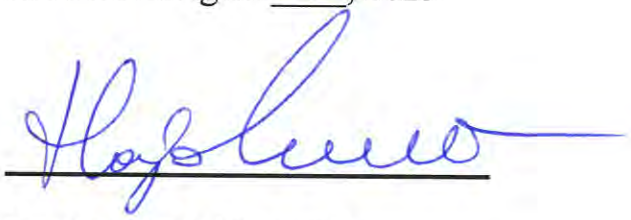


XVI. Revision or Supplementation

481. In this declaration, I have presented my opinions regarding the invalidity of claims 1-9 of the ’142 patent based on the information available to me. My opinions are subject to change in view of opinions provided by the Patent Owner or its expert, or any additional information that I may receive. I reserve the right to supplement my opinions accordingly.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed August 26, 2025



Dr. Marek Hajduczenia

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