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(54) **SYSTEMS AND METHODS FOR FLEXIBLE PERFORMANCE MONITORING DATA ARCHIVING IN PASSIVE OPTICAL NETWORKS**

(71) Applicant: **Verizon Patent and Licensing Inc.**, Basking Ridge, NJ (US)

(72) Inventors: **Denis A. Khotimsky**, Westborough, MA (US); **David J. Baker**, Mechanicsville, VA (US); **Gregory K. Sherrill**, Herndon, VA (US)

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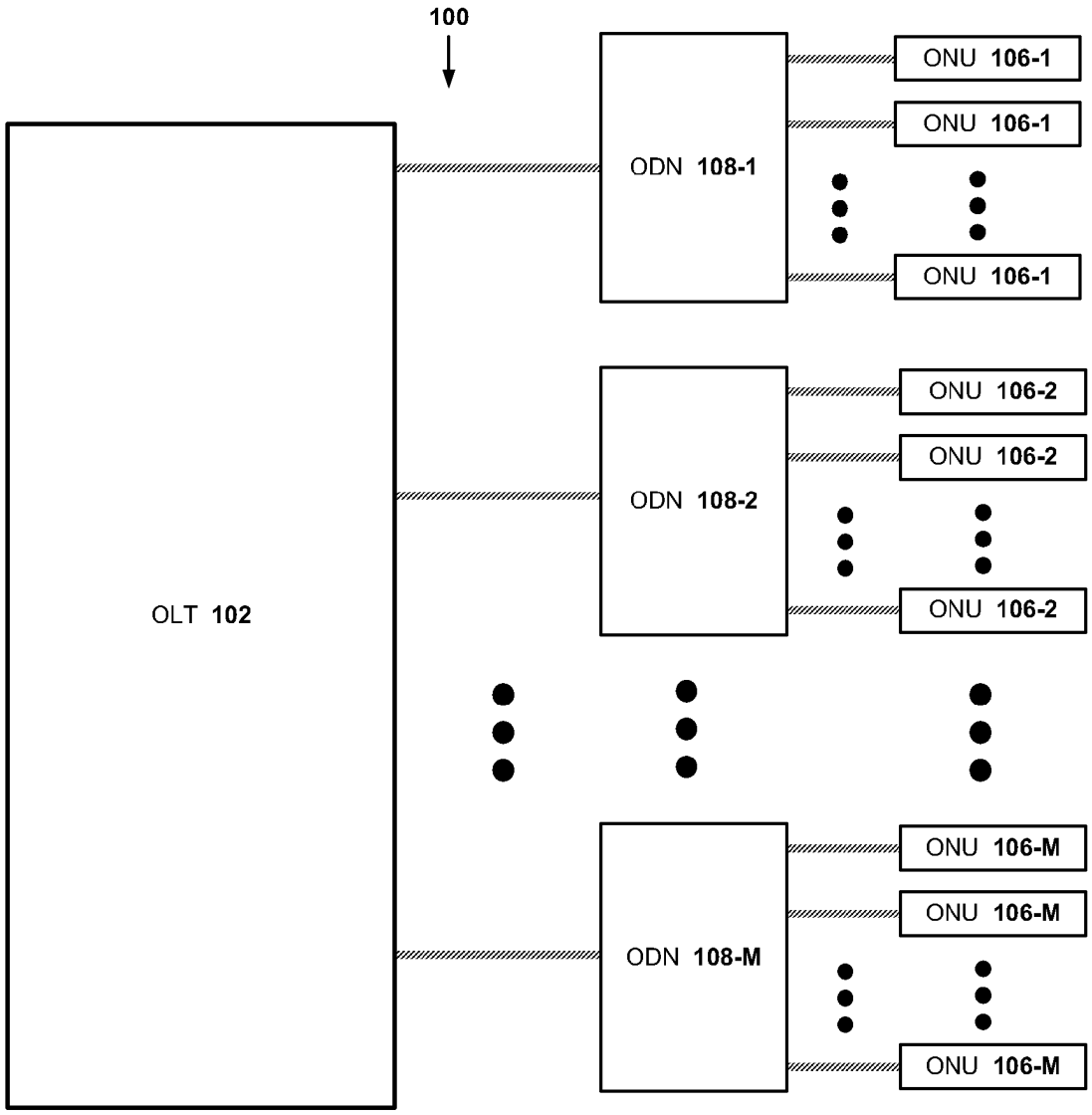
(57) **ABSTRACT**

A device may include a processor. The processor may be configured to, when an Optical Network Unit (ONU) timer reaches an ONU time interval: obtain a value from a history register, in an ONU, which stores a first sum of performance monitoring data at the end of a prior ONU time interval, by issuing a first ONU Control Interface (OMCI) command to the ONU; and store, in a bin accumulation register, the obtained value. Additionally, the processor may be configured to, when a collection timer reaches a collection time interval: obtain a second sum of performance monitoring data collected by the ONU after the prior ONU time interval, by issuing a second OMCI command to the ONU; adjust a result of subtracting a reference value, stored in a reference register, from the second sum; and store the adjusted result.



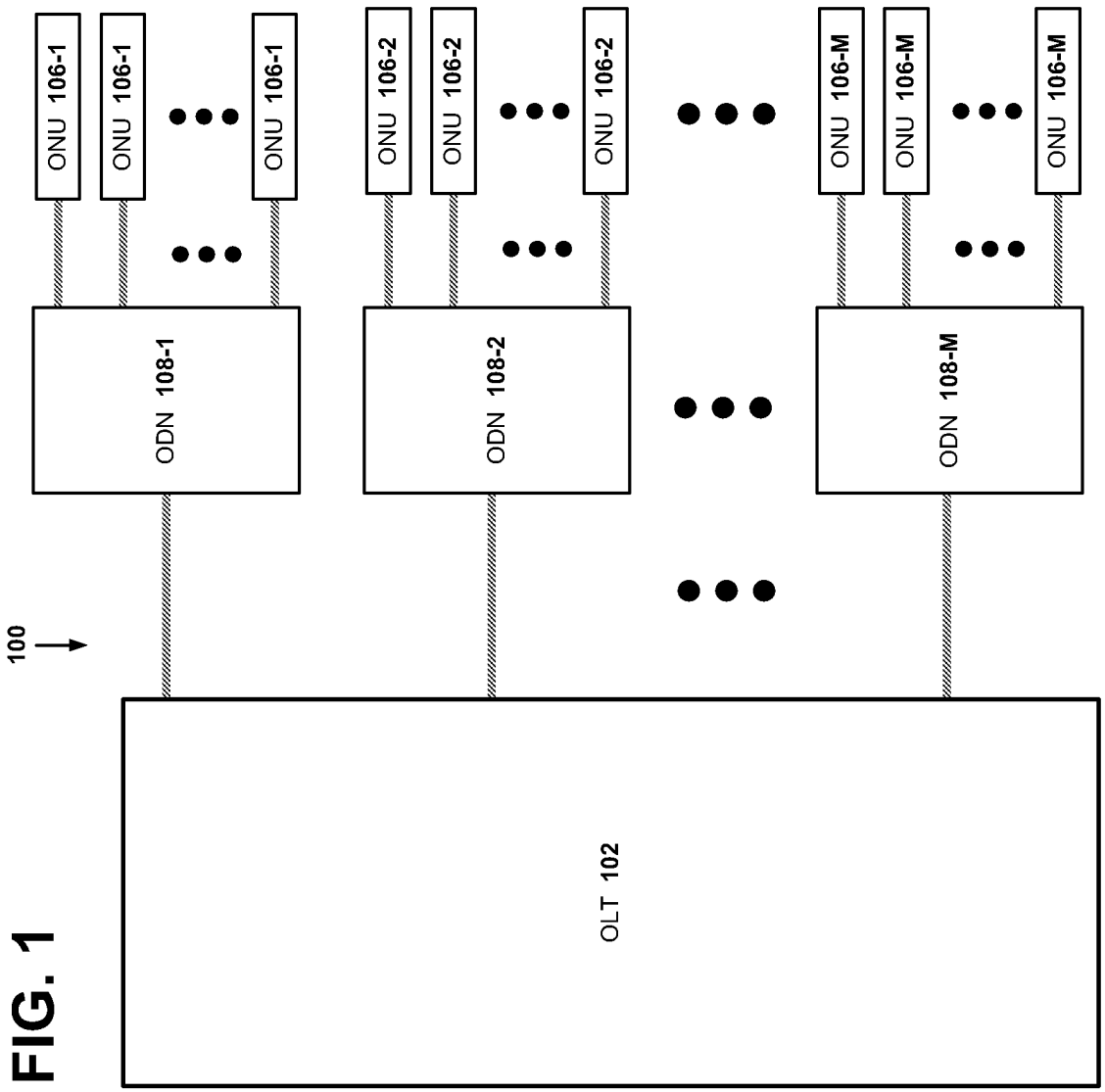

100
OLT 102
ODN 108-1
ODN 108-2
ODN 108-M
ONU 106-1
ONU 106-1
ONU 106-1
ONU 106-2
ONU 106-2
ONU 106-2
ONU 106-M
ONU 106-M
ONU 106-M

FIG. 1

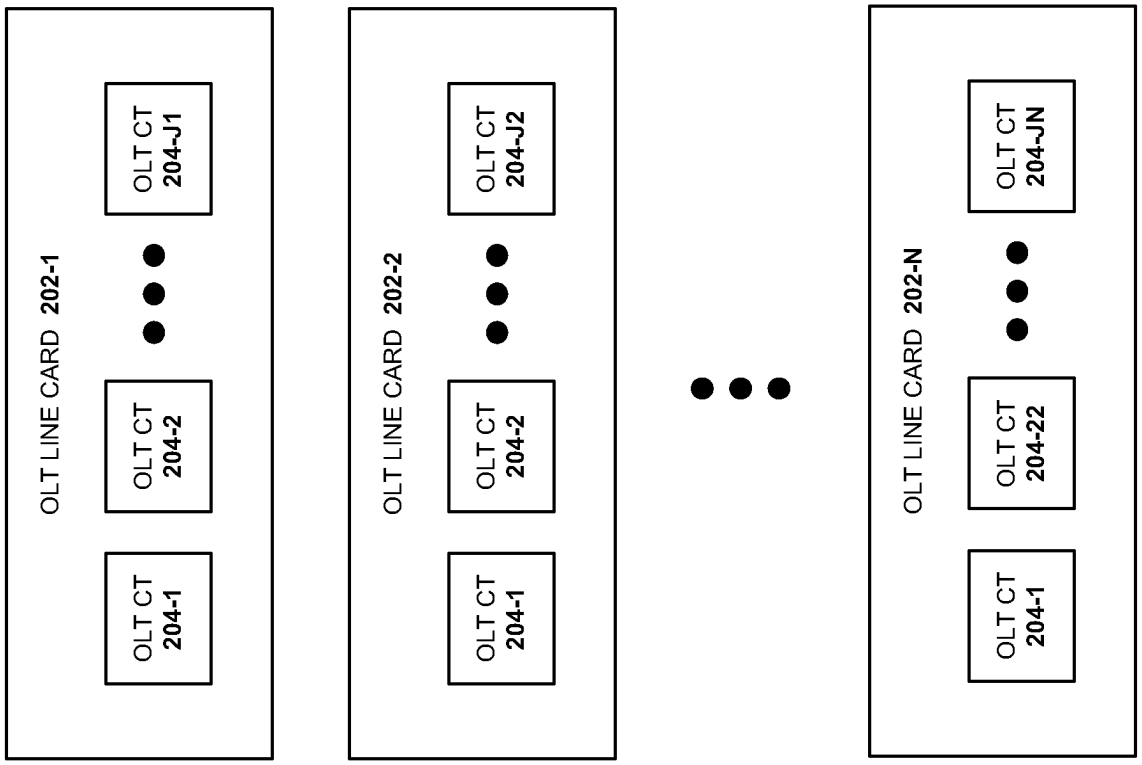

OLT LINE CARD 202-1
OLT CT 204-1
OLT CT 204-2
OLT CT 204-J1
OLT LINE CARD 202-2
OLT CT 204-1
OLT CT 204-2
OLT CT 204-J2
OLT LINE CARD 202-N
OLT CT 204-1
OLT CT 204-22
OLT CT 204-JN
OLT 102

FIG. 2

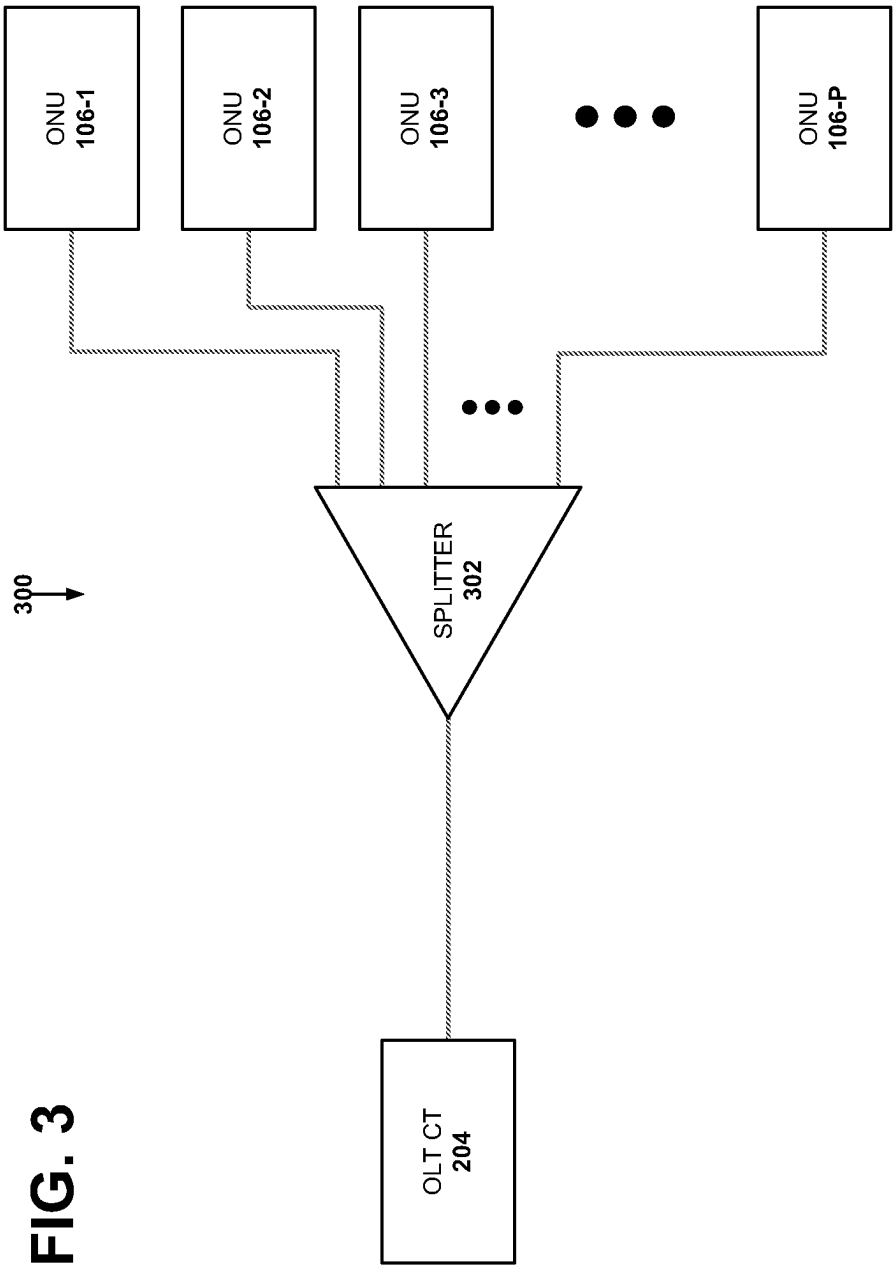

ONU
106-1
ONU
106-2
ONU
106-3
ONU
106-P
SPLITTER
302
300
OLT CT
204

FIG. 3

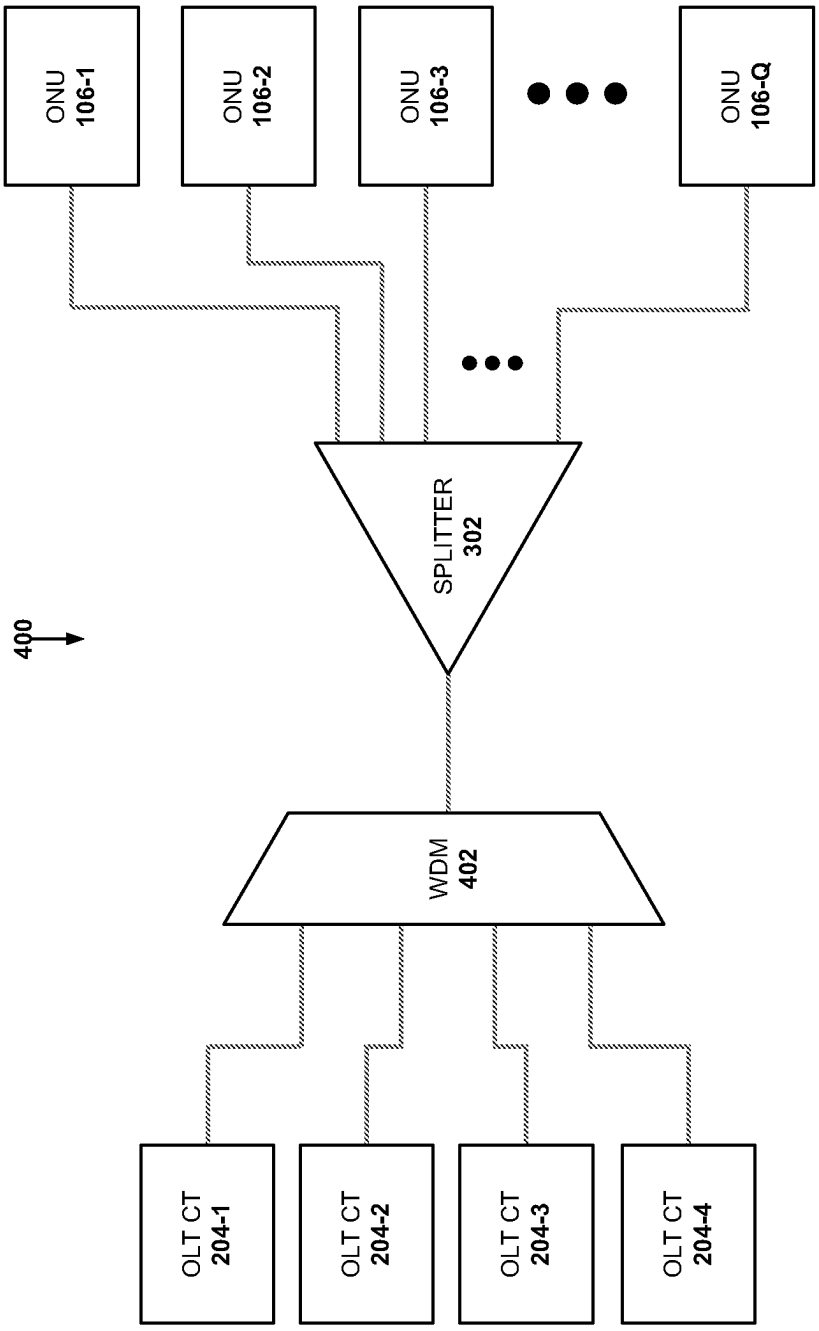

ONU 106-1
ONU 106-2
ONU 106-3
ONU 106-Q
SPLITTER 302
400
WDM 402
OLT CT 204-1
OLT CT 204-2
OLT CT 204-3
OLT CT 204-4

FIG. 4

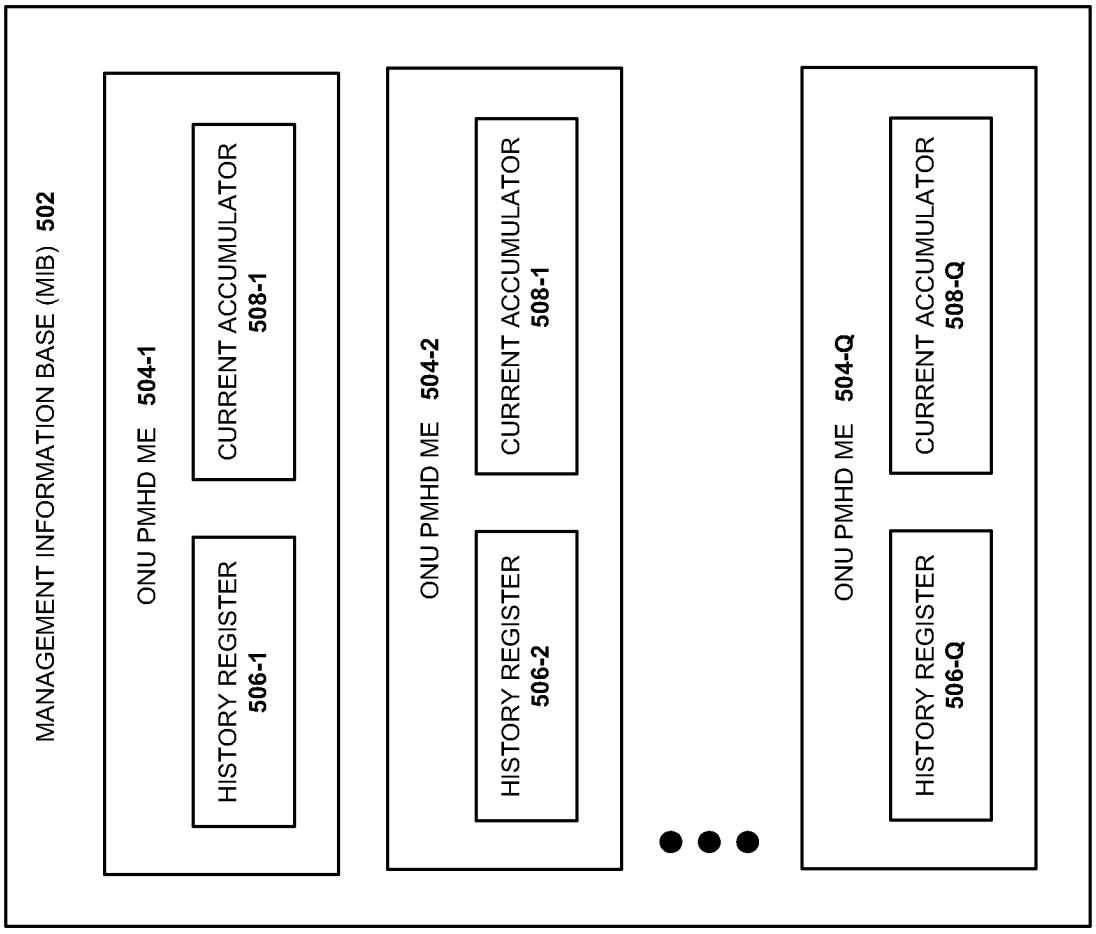

MANAGEMENT INFORMATION BASE (MIB) 502
ONU PMHD ME 504-1
HISTORY REGISTER 506-1
CURRENT ACCUMULATOR 508-1
ONU PMHD ME 504-2
HISTORY REGISTER 506-2
CURRENT ACCUMULATOR 508-1
ONU PMHD ME 504-Q
HISTORY REGISTER 506-Q
CURRENT ACCUMULATOR 508-Q
ONU 106

FIG. 5

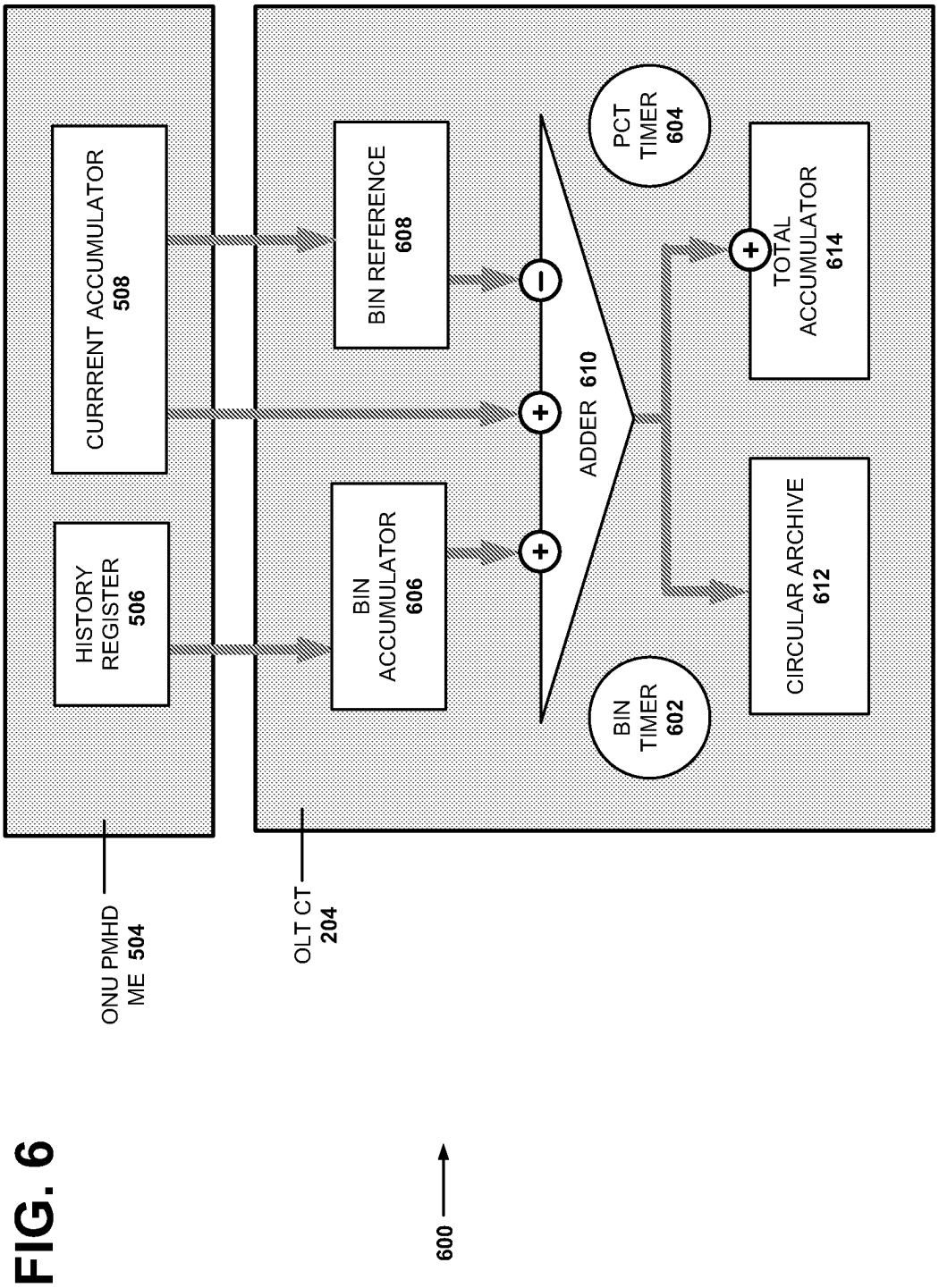

ONU PMHD ME 504
OLT CT 204
HISTORY REGISTER 506
CURRRENT ACCUMULATOR 508
BIN ACCUMULATOR 606
BIN REFERENCE 608
BIN TIMER 602
PCT TIMER 604
ADDER 610
CIRCULAR ARCHIVE 612
TOTAL ACCUMULATOR 614
600

FIG. 6

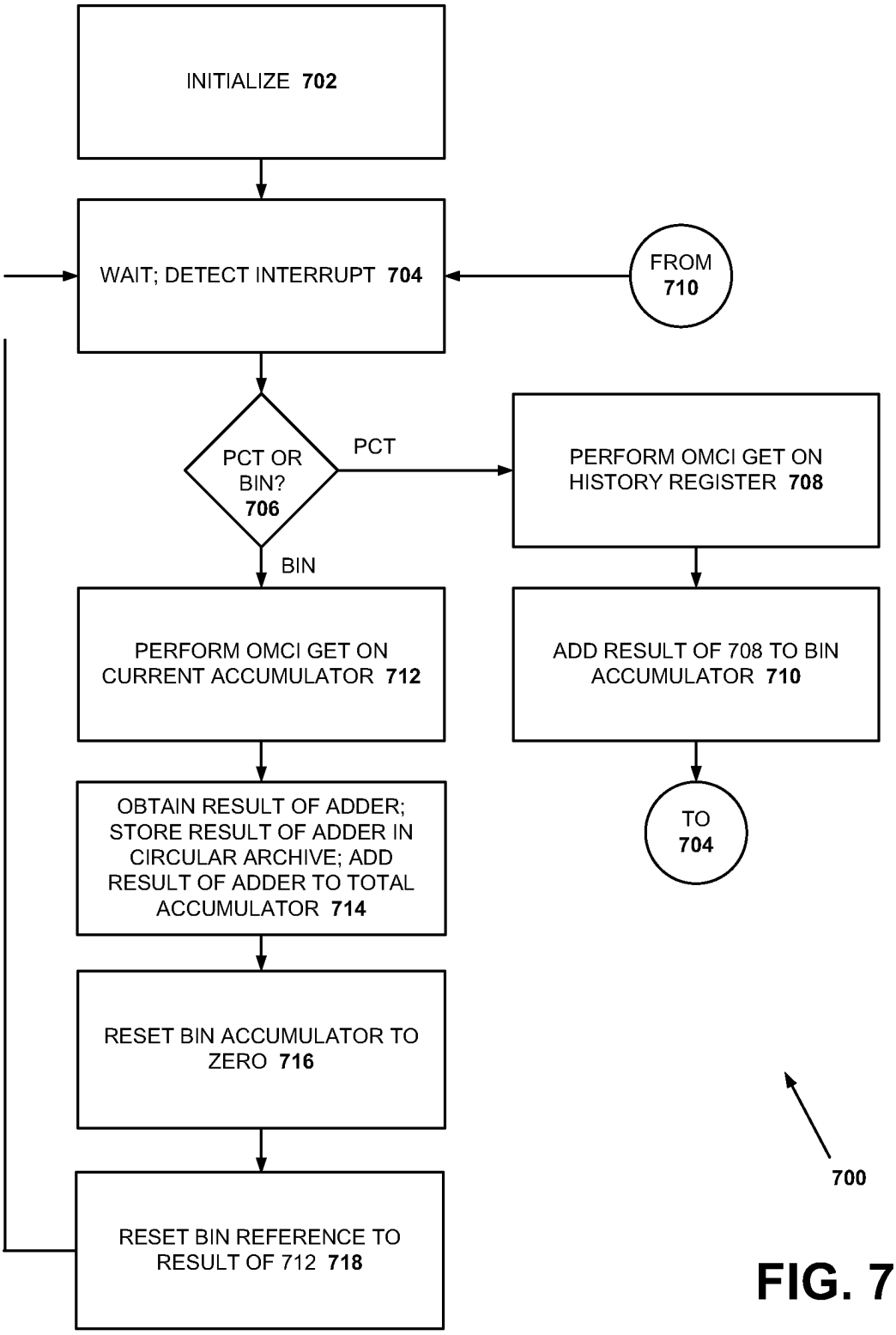
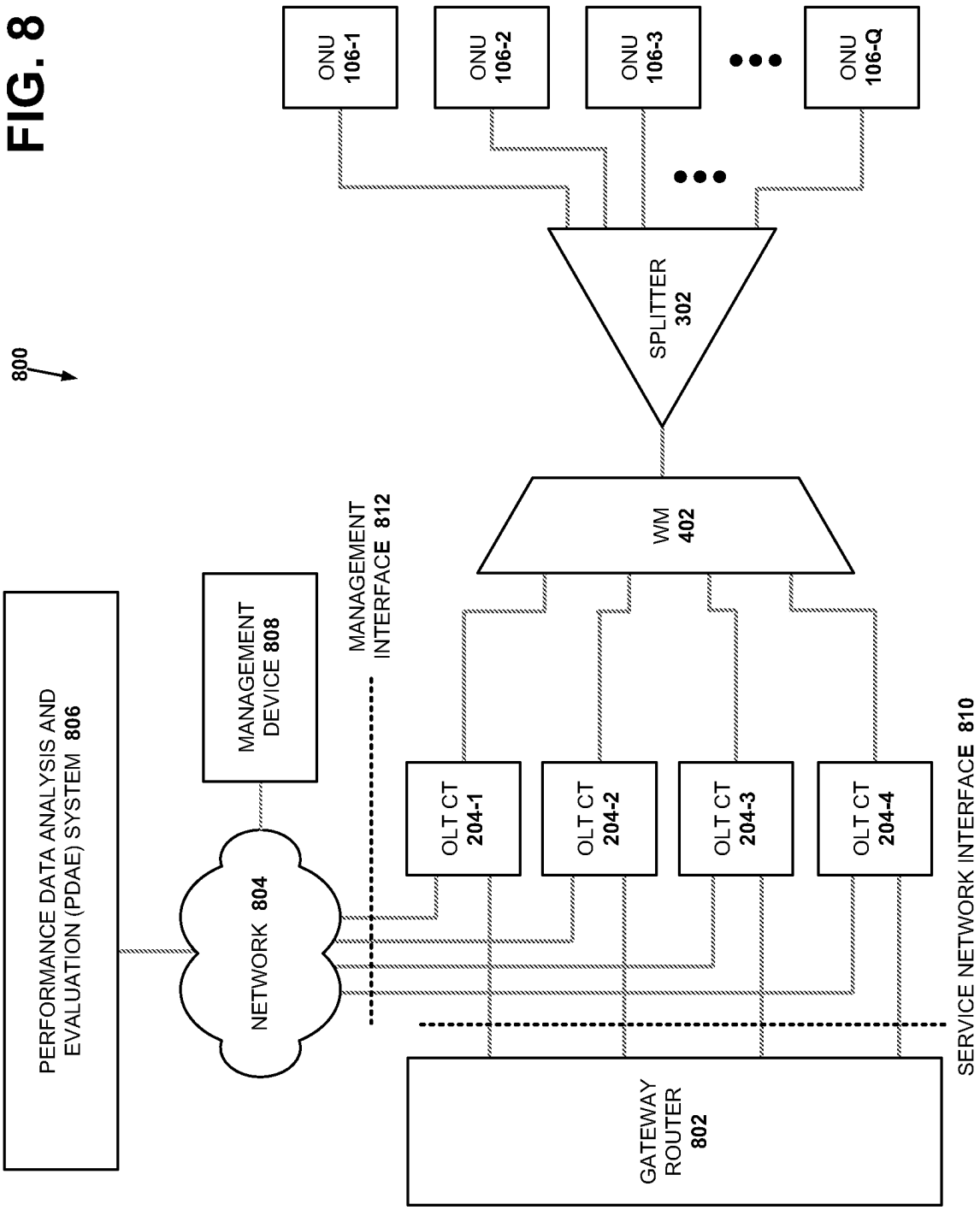

INITIALIZE 702
WAIT; DETECT INTERRUPT 704
FROM 710
PCT OR BIN? 706
PCT
PERFORM OMCI GET ON HISTORY REGISTER 708
BIN
PERFORM OMCI GET ON CURRENT ACCUMULATOR 712
ADD RESULT OF 708 TO BIN ACCUMULATOR 710
TO 704
OBTAIN RESULT OF ADDER; STORE RESULT OF ADDER IN CIRCULAR ARCHIVE; ADD RESULT OF ADDER TO TOTAL ACCUMULATOR 714
RESET BIN ACCUMULATOR TO ZERO 716
RESET BIN REFERENCE TO RESULT OF 712 718
700

FIG. 7

FIG. 8


800
ONU 106-1
ONU 106-2
ONU 106-3
ONU 106-Q
SPLITTER 302
WM 402
MANAGEMENT INTERFACE 812
MANAGEMENT DEVICE 808
PERFORMANCE DATA ANALYSIS AND EVALUATION (PDAE) SYSTEM 806
NETWORK 804
OLT CT 204-1
OLT CT 204-2
OLT CT 204-3
OLT CT 204-4
SERVICE NETWORK INTERFACE 810
GATEWAY ROUTER 802

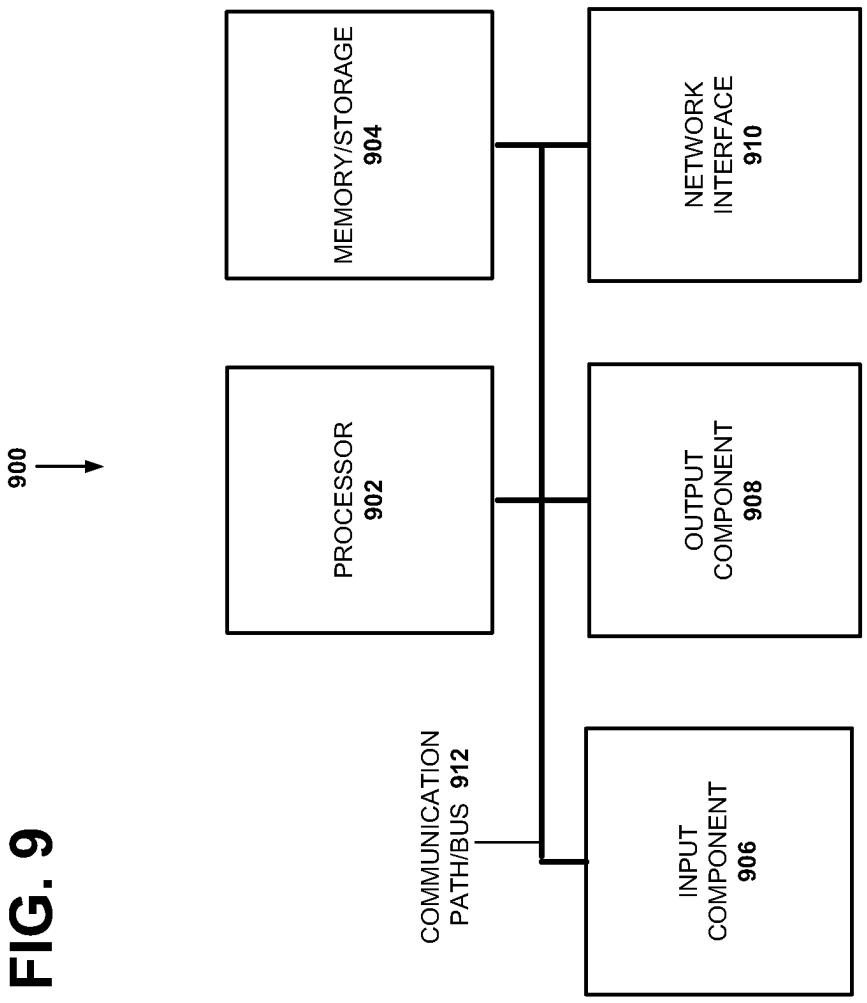

900
PROCESSOR 902
MEMORY/STORAGE 904
OUTPUT COMPONENT 908
NETWORK INTERFACE 910
INPUT COMPONENT 906
COMMUNICATION PATH/BUS 912

FIG. 9

SYSTEMS AND METHODS FOR FLEXIBLE PERFORMANCE MONITORING DATA ARCHIVING IN PASSIVE OPTICAL NETWORKS

BACKGROUND INFORMATION

[0001] A Passive Optical Network (PON) is an optical access network that employs a point-to-multipoint (P2MP) optical fiber topology, called an optical distribution network (ODN), to connect Optical Line Termination (OLT) equipment located at the central office (central node) with multiple Optical Network Unit (ONU) equipment at the customer premises (leaf nodes). An ODN may include optical fibers and passive optical components, such as splitters and combiners. The term ONU may be used interchangeably with Optical Network Terminal (ONT).

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. **1** illustrates an example passive optical network (PON) environment in which systems and methods described herein may be implemented.

[0003] FIG. **2** shows example components of optical line terminal (OLT), according to an implementation.

[0004] FIG. **3** depicts example interconnectivity between an OLT channel termination (CT) and optical network units (ONUs) in a single channel PON, according to an implementation.

[0005] FIG. **4** depicts example interconnectivity between OLT CT devices and ONUs in a multichannel PON, according to an implementation.

[0006] FIG. **5** shows example components of an ONU, according to an implementation.

[0007] FIG. **6** illustrates example components of an OLT CT, according to an implementation.

[0008] FIG. **7** is a flow diagram of an example process that is associated with flexible performance monitoring data archiving, according to an implementation.

[0009] FIG. **8** illustrates an example flexible performance monitoring data archiving system, according to an implementation.

[0010] FIG. **9** depicts example functional components of a network device according to an implementation.

DETAILED DESCRIPTION

[0011] The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

[0012] Systems and methods described herein relate to flexible performance monitoring data archiving. A typical system for archiving performance monitoring data collected from optical network units (ONUs) operates under one or more constraints. For example, an archiving system at a central office may obtain data from ONUs and store the data at fixed, preconfigured time intervals. Archiving performance monitoring data at the fixed time intervals (e.g., 15-minute time intervals), however, may not provide sufficient data granularity for troubleshooting, data analysis, meeting performance evaluation objectives, and/or comparing performances of ONUs over different time scales. The systems and methods described herein permit the network operator to set the archiving times to occur at time intervals set by the network operator, not only at the preconfigured, fixed time intervals.

[0013] FIG. **1** illustrates an example passive optical network (PON) environment **100** in which systems and methods described herein may be implemented. As illustrated, PON environment **100** may include an optical line termination equipment (OLT) **102**, ONUs **106-1** through **106**-M (collectively referred to as ONUs **106** and generically as ONU **106**), and Optical Distribution Networks (ODNs) **108-1** through **108**-M (collectively ODNs **108** and generically ODN **108**). Depending on the implementation, PON environment **100** may include additional, fewer, different, or a different arrangement of components than those illustrated in FIG. **1** (e.g., optical splitters).

[0014] OLT **102** may act as optical signal distribution points for passive optical networks and as uplink points for other networks. OLT **102** may convert signals of a particular type (e.g., electrical signals) to optical signals of one or more wavelengths, multiplex the optical signals, and transmit the multiplexed optical signals to ONUs **106** over PONs **108**. Additionally, OLT **102** may receive optical signals from ONUs **106** over ODNs **108**, demultiplex the optical signals (e.g., demultiplex them in time domain), and convert them to signals of another type. OLT **102** may include components of systems for flexible archiving of performance monitoring data collected from ONUs **106**. Such components permit the archiving times to occur at time intervals set by the network operator, not only at the fixed time intervals associated with ONUs **106**.

[0015] ONUs **106** (also referred to as optical network terminals (ONTs)) may include termination points (e.g., interfaces) of ODNs **108** for end users. For example, an ONU **106** may select an optical signal of a given wavelength (e.g., discard optical signals in channels associated with other wavelengths) from OLT **102**, convert the selected optical signal into an electrical signal that may feed into another device (e.g., a customer premises equipment (CPE) device) in a network local to the end user. In addition, ONU **106** may receive signals of a given type from a local network (e.g., CPE device), convert them into optical signals, multiplex them in time domain, and transmit the multiplexed optical signals upstream toward OLT **102**. In one implementation, an ONU **106** may obtain performance monitoring data and forward the performance monitoring data to OLT **102** at predetermined time intervals.

[0016] Each ODN **108** may include one or more passive optical components, such as optical splitters and optical fibers. At the upstream end, ODN **108** may include a single fiber interface to OLT **102**; and at the downstream ends, ODN **108** may include multiple fiber interfaces to ONUs **106**, where each fiber corresponds to a particular ONU **106**. Each PON that includes ODN **108** may be implemented as a single-channel PON, for example GPON, or a multichannel PON, for example, NG-PON2

[0017] Although PON environment **100** may include components other than those discussed above, they are not illustrated in FIG. **1** for clarity. In addition, depending on the implementation, PON environment **100** may include additional, fewer, different, or a different arrangement of components than those illustrated in FIG. **1**. For example, in some implementations, OLT **102** may include optical wave division multiplexers (WDMs).

[0018] FIG. **2** shows example components of OLT **102** according to an implementation. As shown, OLT **102** may include OLT line cards **202-1** through **202**-N (collectively referred to as OLT line cards **202** and generically as OLT line card **202**). Furthermore, each OLT line card **202** may include OLT channel terminations (CTs) **204-1** through **204**-JN, where 1≤JN≤X and where X is the maximum number of OLT CTs per OLT line card **202**. Although OLT **102** and/or OLT line card **204** may include other components, for clarity, they are not depicted in FIG. **2**.

[0019] Each OLT CT **204** may perform functions that are associated with processing uplink and downlink optical signals in a single channel (defined by a particular wavelength) and functions for performing flexible performance monitoring data archiving. In particular, OLT CT **204** may implement an ONU Management and Control Interface (OMCI). OLT CT **204** may request performance monitoring data from ONUs **106** via the OMCI commands.

[0020] Depending on the implementation, a set of OLT CTs **204** in the same or different OLT chassis may be configured to handle ONUs **106** in a single channel PON environment or to handle ONUs **106** in a multichannel PON environment. For example, the set may comprise OLT CTs **204** that are included in different OLT line cards **202** of the same OLT **102**. In another implementation, the set may comprise two or more OLT CTs **204** that are included in the same OLT line card **202**. In yet another implementation, the set may comprise OLT CTs **204** that are included in OLT line cards **202** in different OLT chassis.

[0021] FIG. **3** depicts example interconnectivity between OLT CT **204** and ONUs **106** in a single channel PON, according to an implementation. As shown, a single-channel PON may be terminated at the upstream single-fiber end by a time division multiplexed OLT CT **204** (referred to as TDM OLT CT **204** or simply as OLT CT **204**) and terminated at the downstream multi-fiber ends by ONUs **106**. As discussed above, in addition to performing various PON functions, OLT CT **204** may obtain performance monitoring data from ONUs **106** at network operator specified collection intervals, archive the obtained performance monitoring data, and/or present the obtained performance monitoring data to the network operator.

[0022] When an optical signal from OLT CT **204** travels down the optical fiber, the optical signal may be split into identical, multiple optical signals via one or more of optical splitter **302** (referred to simply as splitter **302**). Each of the output split signals eventually reach ONUs **106** coupled to the ends of the optical fibers from a splitter **302**. Conversely, uplink optical signals from ONUs **106** may be combined via one or more of splitter **302** and travel upstream over the single optical fiber that feeds OLT CT **204**. The optical signals from ONUs **106** may be at a wavelength different from that of optical signals from OLT CT **204**. In addition, the optical signals from ONUs **106** may be time division multiplexed, to avoid inter-ONU signal interference.

[0023] FIG. **4** depicts example interconnectivity between OLT CT **204** and ONUs **106** in a multichannel PON, according to an implementation. In contrast to single channel PON, multichannel PON may be terminated at the upstream single-fiber end by time and wave division multiplexed OLT CTs **204** (referred to as TWDM OLT CT **204** or simply as OLT CT **204**) and terminated at the downstream multi-fiber ends by ONUs **106**. As discussed above, in addition to performing various PON functions, OLT CTs **204** may obtain performance monitoring data from ONUs **106** via the OMCI interface, archive the obtained performance monitoring data, and/or present the obtained performance monitoring data to a network operator.

[0024] In a multichannel PON, before optical signals from OLT CTs **204** are sent over the single optical fiber, they are wave division multiplexed via wave division multiplexer (WM) **402**. The signals output from WDM **402** are then carried to splitter **302**, which has been described above with reference to FIG. **3**. Because a multichannel PON carries optical signals at various wavelengths, each OLT CT **204** and the corresponding ONUs **106** managed by the OLT CT **204** may be configured to select and process optical signals in a channel associated with a particular wavelength. For example, assume that OLT CT **204-1** transmits optical signals to ONU **106-1** via WDM **402**. ONU **106-1** may receive the optical signals on the channel to which ONU **106-1** is tuned. Similarly, optical signals from ONUs **106** managed by OLT CT **204-1** may be on a channel different from those of other ONUs **106**.

[0025] FIG. **5** shows example components of ONU **106** for obtaining performance monitoring data, according to an implementation. As shown, ONU **106** may include a Management Information Base (MIB) **502**, which in turn may include ONU Performance Monitoring History Data (PMHD) Managed Entities (MEs) **504-1** through **504**-Q (collectively referred to as ONU PMHD MEs **504** and generically as ONU PMHD ME **504**). The number of ONU PMHD ME **504** may correspond to the number of parameters that ONU **106** monitors. Although ONU **106** may include components and subcomponents other than MIB **502** and ONU PMHD MEs **504** (e.g., optical components or electrical components), such components/subcomponents are not shown in FIG. **5** for clarity.

[0026] MIB **502** may include information that OLT **102** (e.g., OLT CT **204**) may access via OMCI messages, such as data maintained by ONU PMHD ME **504**. Each ONU PMHD ME **504** may include a history register **506** and a current accumulator **508**. History register **506** may include, during a data collection time interval, the accumulated sum of the data, in current accumulator **508** at the end of the preceding collection time interval.

[0027] Current accumulator **508** may also store a running sum of particular monitoring data (e.g., a number of packets received, transmitted, number of errors, etc.) from the start of the current collection time window to the present. Current accumulator **508** may continue to accumulate monitored data until the collection period expires.

[0028] History register **506** and current accumulator **508** may be configured to optimize performance. For example, at the expiration of a collection period, history register **506** may be set to zero and current accumulator **508** and history register **506** may swap roles. Without the optimization, at the start of each collection period, the value stored at current accumulator **508** would need to be transferred to history register **506** and current accumulator **508** would need to be reset to zero. With the optimization, only the contents of history register **506** (which immediately becomes current accumulator **508**) has to be set to zero, thereby saving at least one instruction cycle.

[0029] FIG. **6** illustrates example components of an OLT CT **204** for flexible archiving of performance monitoring data, according to an implementation. FIG. **6** also shows components of ONU **106**. OLT CT **204** and ONU **106** may

interact over ODN **108**, which is not shown in FIG. **6**. As depicted, OLT CT **204** may include, for flexible archiving, a bin timer **602**, a Preconfigured Collection Time (PCT) timer **604**, a bin accumulator **606**, a bin reference register **608** (or simply bin reference **608**), an adder **610**, a circular archive **612**, and a total accumulator **614**. These components are implemented to support archiving of performance monitoring data at network operator selected time intervals, herein referred to as bin intervals, and not at PCT intervals.

[0030] Although OLT CT **204** may include other components, such components are not shown in FIG. **6**. Furthermore, in other implementations, OLT CT **204** may include additional, fewer, different, or a different arrangement of components for performance monitoring data archiving than those illustrated in FIG. **6**. For example, OLT CT **204** may instantiate an additional set of components **602**-**610** and **614** for each additional ONU PMHD ME **504** that OLT CT **204** manages. Depending on the implementation, OLT CT **204** may share circular archive **612** for storing data from multiple ONU PMHD MEs **504**, share circular archive **612** with other OLT CTs **204**, or maintain an individual circular archive **612** for each ONU PMHD ME **504**.

[0031] Bin timer **602** may track elapsed time starting from the prior end of a time window (a bin collection period) that spans a bin interval. When bin timer **602** reaches the end of the current bin collection period, bin timer **602** may alert OLT CT **204** that the current bin collection period has expired. Similarly, PCT timer **604** may track elapsed time starting from the prior end of a PCT collection period. When PCT timer **604** reaches the end of the current PCT collection period, PCT timer **604** may alert OLT CT **204** that the current PCT collection window has expired. Bin timer **602** and PCT timer **604** are automatically reset (e.g., set to zero) at their expiry (e.g., the timer reaches the end of the interval).

[0032] Bin accumulator **606** may store the value of history register **506** at the end of a PCT collection period. In addition, bin accumulator **602** may be set to zero at the end of a bin collection period. Bin reference **608** may store the value of current accumulator **508** at each expiration of a bin collection period.

[0033] Adder **610** may provide a result of adding the values of bin accumulator **606** and current accumulator **508**, less the value of bin reference **608** and provide the result to circular archive **612** and total accumulator **614**. Circular archive **612** may store, in a chronological manner, records of the outputs from adder **610**. Each of the records may include an output provided by adder **610** along with a timestamp, an identifier (ID) associated with ONU **106** managed by OLT CT **204**, an ID of OLT CT **204**, the time interval during which the data was collected, etc. When a storage space allocated for circular archive is exhausted, circular archive **610** may overwrite the archived data, starting from the earliest record. Total accumulator **614** may store the sum of the output from adder **610** and the prior value of total accumulator **614**.

[0034] FIG. **7** is a flow diagram of an example process **700** that is associated with components of OLT CT **204** for flexible performance monitoring data archiving, according to an implementation. Assume that ONU **106** stores a count of occurrences of particular events (e.g., packet errors) in current accumulator **508** and stores, in history register **506**, the prior value of current accumulator **508** at the end of the PCT collection period. Also, assume that the network operator has set a bin interval to a value smaller than the PCT interval.

[0035] As shown, process **700** may include initialization of registers, accumulators, and archives (block **702**). For example, OLT CT **204** may set bin accumulator **606** to zero, the bin reference **608** to zero, delete or remove all records from circular archive **612**, set total accumulator **614** to zero, and reset bin timer **602** and PCT timer **604**. In addition, OLT CT **204** may issue OMCI commands to ONU PMHD ME **504** to set history register **506** and current accumulator **508** to zero.

[0036] Process **700** may further include waiting for an interrupt to be generated by bin timer **602** upon reaching the bin interval or by PCT timer **604** upon reaching the PCT interval (block **704**); and, after waiting, being interrupted or detecting an interrupt (block **704**). When the interrupt generated, if the interrupt is has been generated by PCT timer **604** indicating that it has expired (block **706**: PCT), OLT CT **204** may issue an OMCI command (e.g., OMCI GET message) to ONU **106** to obtain the value of history register **506** within ONU PMHD ME **504** (block **708**). Next, OLT CT **204** may set bin accumulator **606** to the obtained value from history register **506** (block **710**). Process **700** may then proceed to block **704**.

[0037] At block **706**, if the interrupt has been generated by bin timer **602** (block **706**: BIN), OLT CT **204** may obtain the value of current accumulator **508** from ONU PMHD ME **504** by performing the OMCI GET on current accumulator **508** of ONU PMHE ME **504** (block **712**). Next, OLT CT **204** may obtain an output value of adder **610** (i.e., evaluate the sum of the value obtained from current accumulator **608** at block **712** and the value of bin accumulator **606**, less the value of bin reference **608** (block **714**). OLT CT **204** may store the output of adder **610** along with other bookkeeping information (e.g., timestamp, the ID of ONU PMHD ME **504**, the ID of OLT CT **204**, the bin collection interval, etc.) as a record in circular archive **612** (block **714**). Furthermore, OLT CT **204** may obtain the sum of the output of adder **610** and the value of total accumulator **614** and store the sum in total accumulator **614** (block **714**). Thereafter, OLT CT **204** may reset bin accumulator **606** to zero (block **716**) and reset the bin reference **608** to the value of current accumulator **508** obtained at block **712** (block **718**). Process **700** may then return to block **704**. In this manner, performance monitoring data may be stored at various granularity, by setting a bin timer **602** to a shorter time interval than the PCT time interval. The data may then be used to analyze performance in PON environment **100**, in a manner not possible with data collected only at PCT intervals.

[0038] FIG. **8** illustrates an example flexible performance monitoring data archiving system **800**, according to an implementation. As shown, system **800** may include a gateway router **802**, a local network **804**, a Performance Data Analysis and Evaluation (PDAE) system **806**, one or more management device **808**, and components of FIG. **4** (e.g., OLT CTs **204**, WDM **402**, splitter **302**, and ONUs **106**). Depending on the implementation, system **800** may include additional, fewer, different, or a different arrangement of components than those depicted in FIG. **8**.

[0039] Gateway router **802** may provide a point of entry/exit for packets to/from OLT CTs **204** and network **804** via a service network interface **810**. Network **804** may provide connectivity to components of system **800**, such as PDAE

system **806**, management device **808**, and OLT CTs **204**. PDAE system **806** may provide mechanisms for accessing performance monitoring data, conducting analysis, and troubleshooting. For example, a network operator may use PDAE system **806** to access data (e.g., packet errors) in circular archive **612** collected over a particular time interval by a set of ONUs **106**, view the data (e.g., as graphs, charts, etc.), obtain data statistics, etc. In one implementation, PDAE system **806** may permit a network operator who accesses PDAE system **806** via a client application (e.g., a browser) to use the flexible performance monitoring data archiving capabilities of one or more OLT CTs **204** through management interface **812**. For example, a network operator may set the bin interval for one or more OLT CTs **204**, stop the data archiving process, restart the data archiving process, etc. Management device **808** may include a client application for accessing PDAE system **806** and using PDAE system **806**.

[0040] FIG. **9** depicts exemplary components of an exemplary network device **900**. Network device **900** may correspond to or be included in any of the devices and/or components illustrated in FIGS. **1-6** and **8** (e.g., OLT elements **104**, OLT CT **204**, ONU **106**, gateway router **802**, network **804**, PDAE system **806**, etc.). In some implementations, network devices **900** may be part of a hardware network layer on top of which other network layers and network functions (NFs) may be implemented.

[0041] As shown, network device **900** may include a processor **902**, memory/storage **904**, input component **906**, output component **908**, network interface **910**, and communication path **912**. In different implementations, network device **900** may include additional, fewer, different, or different arrangement of components than the ones illustrated in FIG. **9**. For example, network device **900** may include line cards, switch fabrics, modems, etc.

[0042] Processor **902** may include a processor, a microprocessor, an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), programmable logic device, chipset, application specific instruction-set processor (ASIP), system-on-chip (SoC), central processing unit (CPU) (e.g., one or multiple cores), microcontrollers, and/or other processing logic (e.g., embedded devices) capable of controlling network device **900** and/or executing programs/instructions.

[0043] Memory/storage **904** may include static memory, such as read only memory (ROM), and/or dynamic memory, such as random access memory (RAM), or onboard cache, for storing data and machine-readable instructions (e.g., programs, scripts, etc.). Memory/storage **904** may also include a CD ROM, CD read/write (R/W) disk, optical disk, magnetic disk, solid state disk, holographic versatile disk (HVD), digital versatile disk (DVD), and/or flash memory, as well as other types of storage device (e.g., Micro-Electromechanical system (MEMS)-based storage medium) for storing data and/or machine-readable instructions (e.g., a program, script, etc.). Memory/storage **904** may be external to and/or removable from network device **900**. Memory/storage **904** may include, for example, a Universal Serial Bus (USB) memory stick, a dongle, a hard disk, off-line storage, a Blu-Ray® disk (BD), etc. Memory/storage **904** may also include devices that can function both as a RAM-like component or persistent storage, such as Intel® Optane memories. Depending on the context, the term "memory," "storage," "storage device," "storage unit," and/or "medium" may be used interchangeably. For example, a "computer-readable storage device" or "computer-readable medium" may refer to both a memory and/or storage device.

[0044] Input component **906** and output component **908** may provide input and output from/to a user to/from network device **900**. Input/output components **906** and **908** may include a display screen, a keyboard, a mouse, a speaker, a microphone, a camera, a DVD reader, USB lines, and/or other types of components for obtaining, from physical events or phenomena, to and/or from signals that pertain to network device **900**.

[0045] Network interface **910** may include a transceiver (e.g., a transmitter and a receiver) for network device **900** to communicate with other devices and/or systems. For example, via network interface **910**, network device **900** may communicate over a network, such as the Internet, an intranet, cellular, a terrestrial wireless network, a satellite-based network, optical network, etc. Network interface **910** may include a modem, an Ethernet interface to a LAN, and/or an interface/connection for connecting network device **900** to other devices.

[0046] Communication path or bus **912** may provide an interface through which components of network device **900** can communicate with one another.

[0047] Network device **900** may perform the operations described herein in response to processor **902** executing software instructions stored in a non-transient computer-readable medium, such as memory/storage **904**. The software instructions may be read into memory/storage **904** from another computer-readable medium or from another device via network interface **910**. The software instructions stored in memory/storage **904**, when executed by processor **902**, may cause processor **902** to perform one or more of the processes that are described herein.

[0048] In this specification, various preferred embodiments have been described with reference to the accompanying drawings. It will be evident that modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope of the invention as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

[0049] In the above, while series of actions have been described with reference to FIG. **7**, the order of the actions may be modified in other implementations. In addition, non-dependent actions may represent actions that can be performed in parallel and in different orders. Furthermore, each of actions illustrated may include one or more other actions.

[0050] It will be apparent that aspects described herein may be implemented in many different forms of software, firmware, and hardware in the implementations illustrated in the figures. The actual software code or specialized control hardware used to implement aspects does not limit the invention. Thus, the operation and behavior of the aspects were described without reference to the specific software code—it being understood that software and control hardware can be designed to implement the aspects based on the description herein.

[0051] Further, certain portions of the implementations have been described as "logic" that performs one or more functions. This logic may include hardware, such as a processor, a microprocessor, an application specific inte-

grated circuit, or a field programmable gate array, software, or a combination of hardware and software.

[0052] To the extent the aforementioned embodiments collect, store or employ personal information provided by individuals, it should be understood that such information shall be collected, stored, and used in accordance with all applicable laws concerning protection of personal information. The collection, storage and use of such information may be subject to consent of the individual to such activity, for example, through well known "opt-in" or "opt-out" processes as may be appropriate for the situation and type of information. Storage and use of personal information may be in an appropriately secure manner reflective of the type of information, for example, through various encryption and anonymization techniques for particularly sensitive information.

[0053] No element, block, or instruction used in the present application should be construed as critical or essential to the implementations described herein unless explicitly described as such. Also, as used herein, the articles "a," "an," and "the" are intended to include one or more items. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. A device comprising:

a processor to:

when an Optical Network Unit (ONU) timer reaches an ONU time interval,

obtain a value from a history register, in an ONU, which stores a first sum of performance monitoring data at the end of a prior ONU time interval, by issuing a first ONU Control Interface (OMCI) command to the ONU; and

store, in a bin accumulation register, the obtained value; and

when a collection timer reaches a collection time interval,

obtain a second sum of performance monitoring data collected by the ONU after the prior ONU time interval, by issuing a second OMCI command to the ONU;

adjust a result of subtracting a reference value, stored in a reference register, from the second sum; and

store the adjusted result.

2. The device of claim **1**, wherein when the collection timer reaches the collection time interval, the processor is further configured to:

store the second sum in the reference register.

3. The device of claim **1**, wherein when the collection timer reaches the collection time interval, the processor is further configured to:

set the bin accumulation register to zero.

4. The device of claim **3**, wherein when the processor adjusts the result, the processor is configured to:

add a value stored in the bin accumulation register to the result.

5. The device of claim **1**, wherein the processor is further configured to:

set the collection timer to a length of time specified in a message from another device via a management interface.

6. The device of claim **1**, wherein the device comprises an optical line terminal (OLT) channel termination (CT) device.

7. The device of claim **1**, wherein when the collection timer reaches the collection time interval,

obtain a third sum of the adjusted value and a value stored at a total accumulator; and

store the third sum in the total accumulator.

8. The device of claim **1**, wherein when the processor stores the adjusted result, the processor is configured to:

store the adjusted result in a circular archive.

9. The device of claim **1**, wherein when the ONU timer reaches the ONU time interval, the ONU is configured to:

store, in the history register, a third sum of performance monitoring data, collected by the ONU.

10. A method comprising:

when an Optical Network Unit (ONU) timer reaches an ONU time interval,

obtaining a value from a history register, in an ONU, which stores a first sum of performance monitoring data at the end of a prior ONU time interval, by issuing a first ONU Control Interface (OMCI) command to the ONU; and

storing, in a bin accumulation register, the obtained value; and

when a collection timer reaches a collection time interval,

obtaining a second sum of performance monitoring data collected by the ONU after the prior ONU time interval, by issuing a second OMCI command to the ONU;

adjusting a result of subtracting a reference value, stored in a reference register, from the second sum; and

storing the adjusted result.

11. The method of claim **10**, further comprising, wherein when the collection timer reaches the collection time interval,

storing the second sum in the reference register.

12. The method of claim **10**, further comprising, wherein when the collection timer reaches the collection time interval,

setting the bin accumulation register to zero.

13. The method of claim **10**, wherein adjusting the result comprises:

adding a value stored in the bin accumulation register to the result.

14. The method of claim **10**, further comprising:

setting the collection timer to a length of time specified in a message from another device via a management interface.

15. The method of claim **10**, wherein storing the adjusted result includes:

storing the adjusted result by an optical line terminal (OLT) channel termination (CT) device.

16. The method of claim **10**, further comprising, when the collection timer reaches the collection time interval,

obtaining a third sum of the adjusted value and a value stored at a total accumulator; and

storing the third sum in the total accumulator.

17. The method of claim **10**, wherein storing the adjusted result includes:

storing the adjusted result in a circular archive.

18. The method of claim **10**, further comprising, wherein when the ONU timer reaches the ONU time interval,

storing, in the history register included in the ONU, a third sum of performance monitoring data, collected by the ONU.

19. A non-transitory computer-readable medium comprising processor-executable instructions which, when executed by a processor in a device, cause the processor to:

when an Optical Network Unit (ONU) timer reaches an ONU time interval,

obtain a value from a history register, in an ONU, which stores a first sum of performance monitoring data at the end of a prior ONU time interval, by issuing a first ONU Control Interface (OMCI) command to the ONU; and

store, in a bin accumulation register, the obtained value; and

when a collection timer reaches a collection time interval,

obtain a second sum of performance monitoring data collected by the ONU after the prior ONU time interval, by issuing a second OMCI command to the ONU;

adjust a result of subtracting a reference value, stored in a reference register, from the second sum; and

store the adjusted result.

20. The non-transitory computer-readable medium of claim **19**, wherein when the ONU timer reaches the ONU time interval, the ONU is configured to:

store, in the history register, a third sum of performance monitoring data, collected by the ONU.

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