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(54) **OUTAGE ANALYSIS SYSTEM**

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(57) **ABSTRACT**

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A device may receiving alarms identifying failures of network elements, create a site table that includes a list of sites at which the alarms are generated and a number of alarms for each of the sites, determine whether an outage has occurred based on the alarms, analyze whether the outage is a false outage based on a failure of a probe that generates the alarms, and provide a notification that includes the site table, an indication of whether the outage has occurred, or an indication whether the outage is a false outage.

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Related U.S. Application Data

(63) Continuation of application No. 12/055,410, filed on Mar. 26, 2008, now Pat. No. 8,509,093.

DATE 104	TIME 106	SEVERITY 108	PROBE 110	LINK/NODE 112	FAILURE TYPE 114	
1/02/2008	15:27:06	CRITICAL	GEOPROBE_SNMT	FET-TP2-N12	NODE ISOLATED	102-1
1/02/2008	15L27:05	MAJOR	GEOPROBE_SNMT	FET-TP2-N12-MCI-TP1	LINKSET UNAVAILABLE	102-2
1/02/2008	15:26:10	CRITICAL	WORNJETSSG	000006	LINKSET UNAVAILABLE	102-3
• • • • • •						
1/02/2008	15:26:10	CRITICAL	WORNJETSSG	000032	NODE ISOLATED	102-M

DATE 104	TIME 106	SEVERITY 108	PROBE 110	LINK/NODE 112	FAILURE TYPE 114
1/02/2008	15:27:06	CRITICAL	GEOPROBE_SNMT	FET~TP2~N12	NODE ISOLATED 102-1
1/02/2008	15L27:05	MAJOR	GEOPROBE_SNMT	FET~TP2~N12~MCI~TP1	LINKSET UNAVAILABLE 102-2
1/02/2008	15:26:10	CRITICAL	WORNJETSSG	000006	LINKSET UNAVAILABLE 102-3
1/02/2008	15:26:10	CRITICAL	WORNJETSSG	000032	NODE ISOLATED 102-M

Fig. 1

SITE 204	COUNT 206	
PMM	318	202-1
NOR	88	202-2
• • •		
PYM	67	202-S

200

Fig. 2

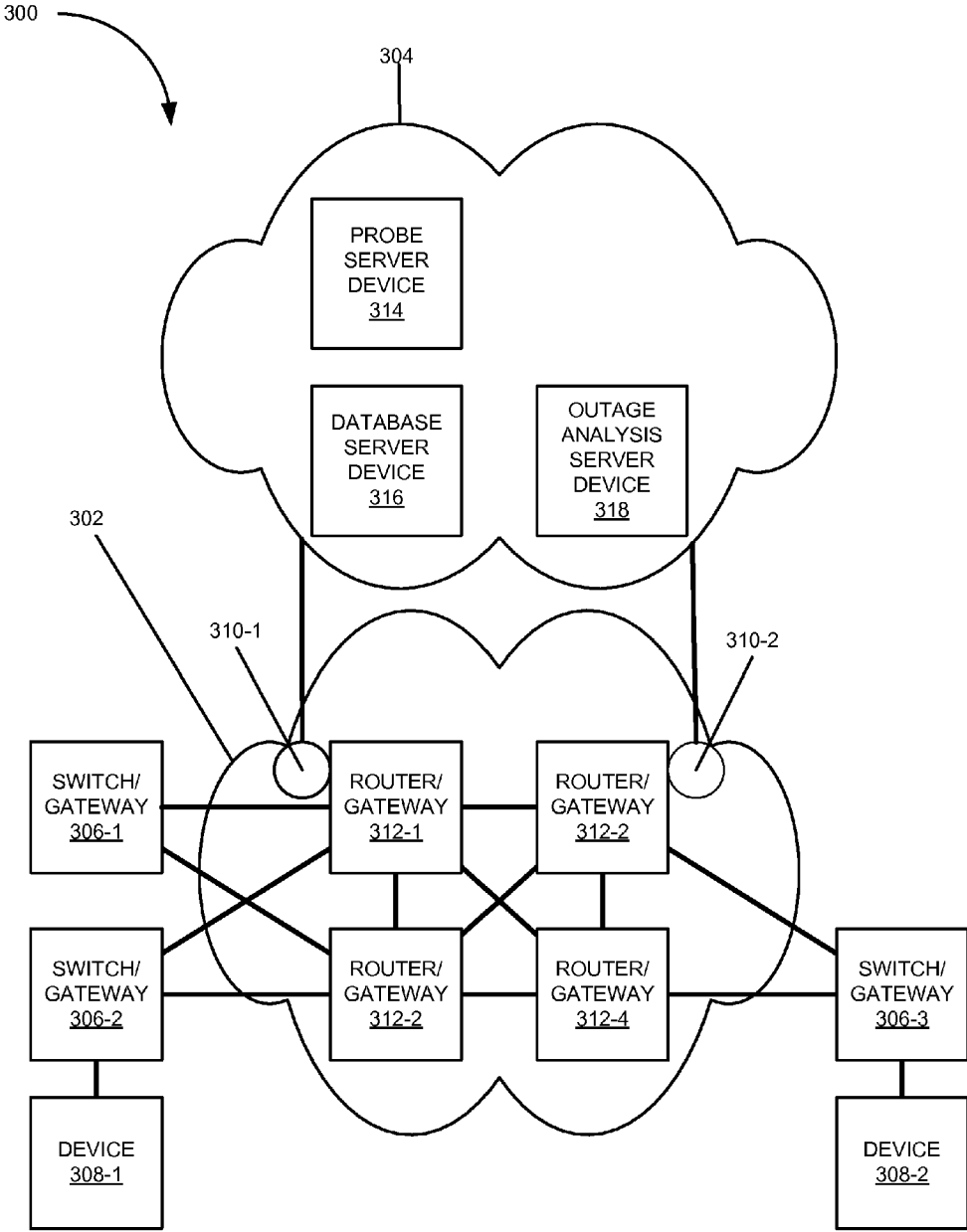


Fig. 3

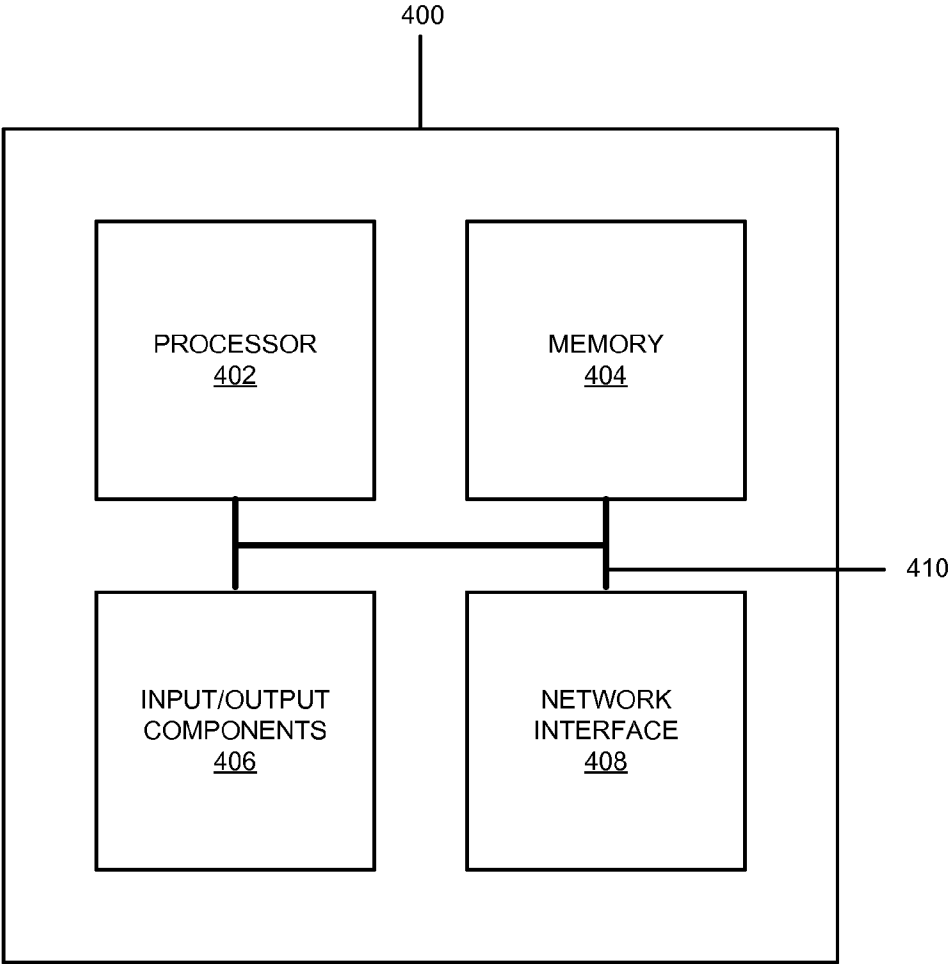


Fig. 4

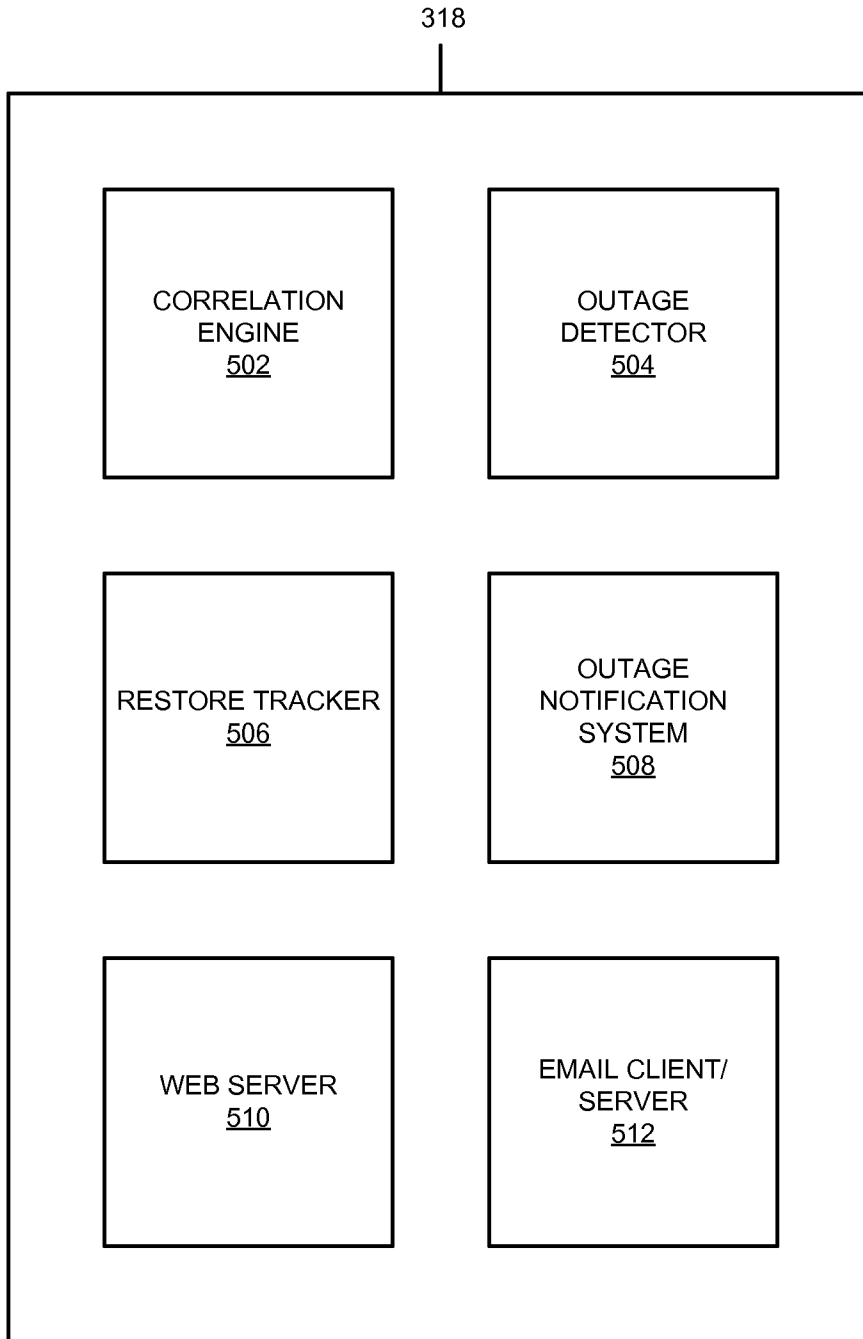


Fig. 5

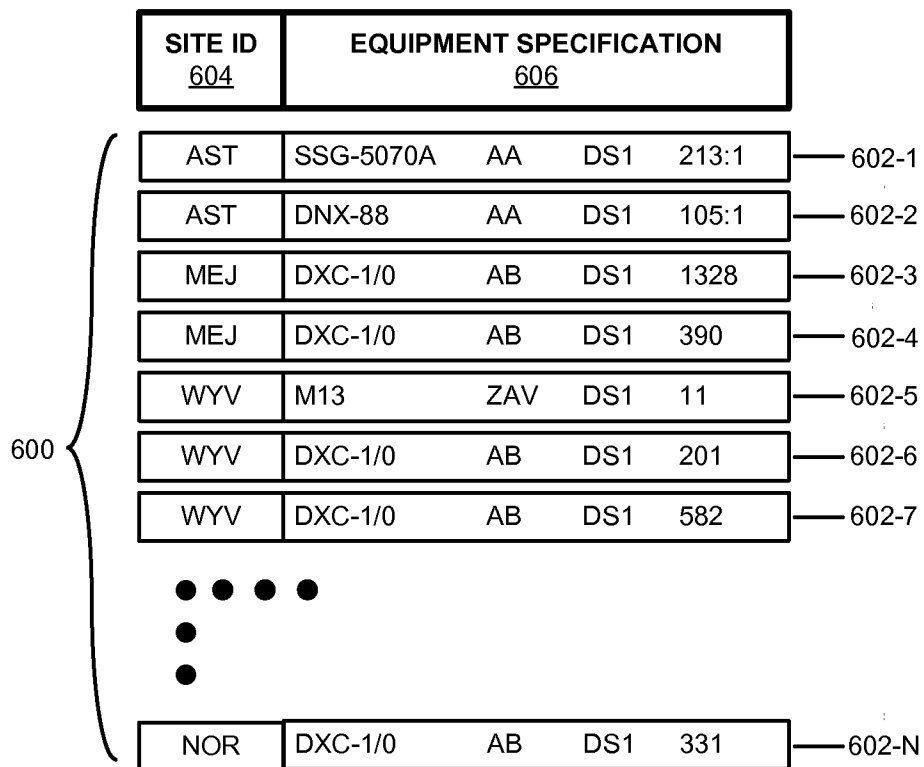


Fig. 6

SITE 704	COUNT 706	
AST	318	702-1
NOR	88	702-2
MEJ	67	702-3
● ● ● ●		
●		
●		
WYV	67	702-P

700

Fig. 7A

SITE 712	DS1 714	COUNT 716	
NOR	DXC-1/0 AA DS1 773	9	710-1
AST	DXN-88 AA DS1 105	6	710-2
● ● ● ●			
●			
●			
WYV	DXC-1/0 AB DS1 582	6	710-Q

708

Fig. 7B

SITE 722	DS3 724	COUNT 726	
WYV	M13 ZAV	12	720-1
PYM	M13 ZIH	6	720-2
● ● ● ●			
●			
●			
AST	DNX-88 AA	6	720-R

718

Fig. 7C

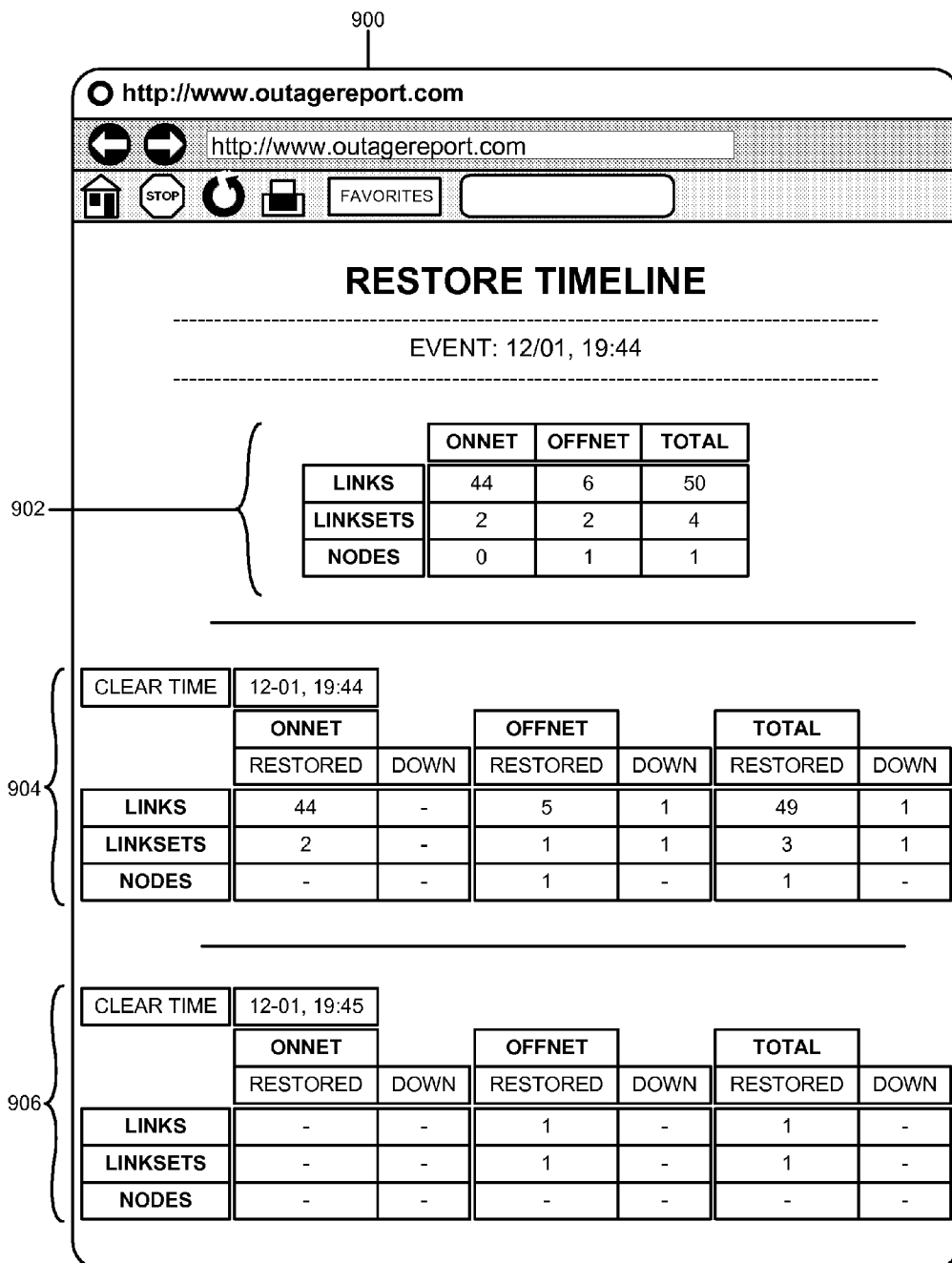


Fig. 9A

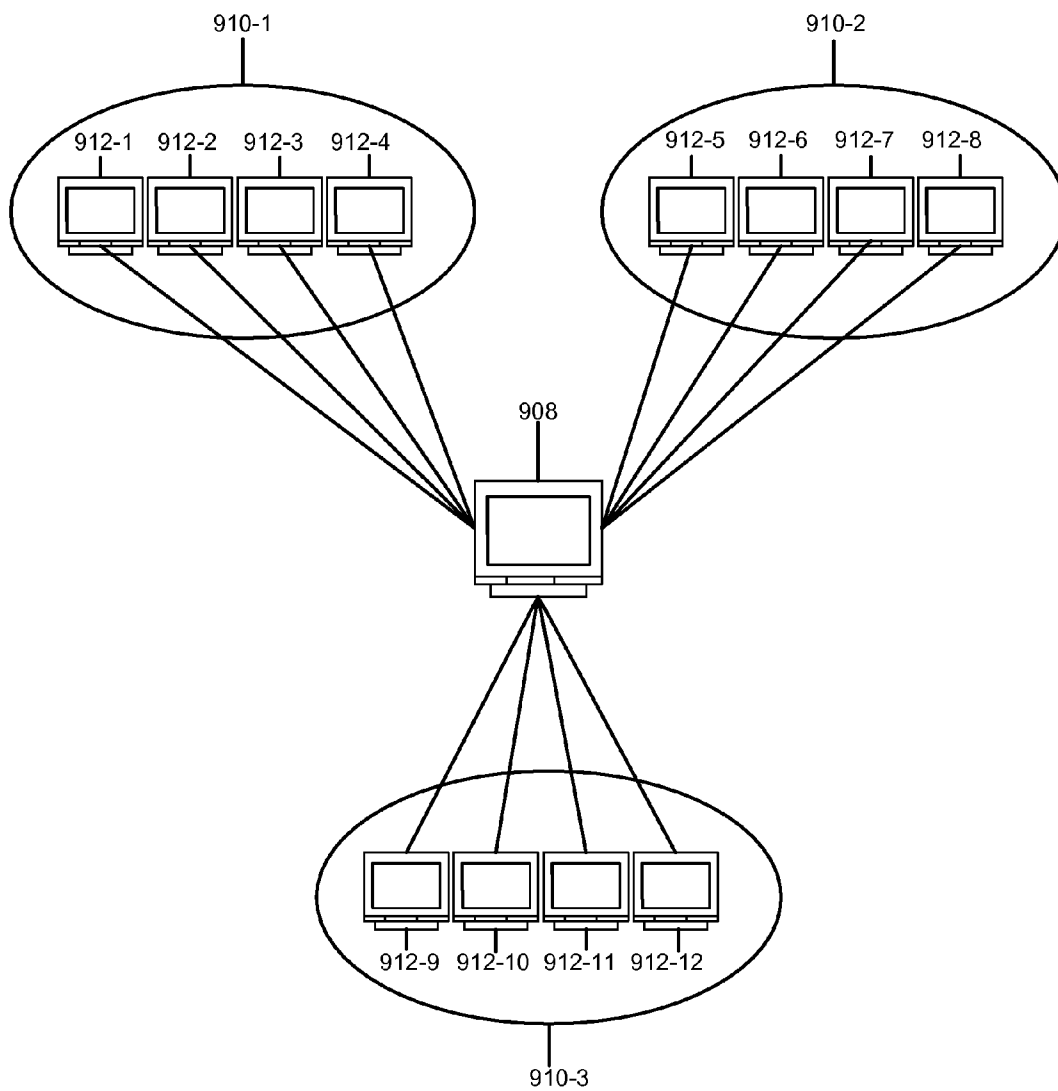


Fig. 9B

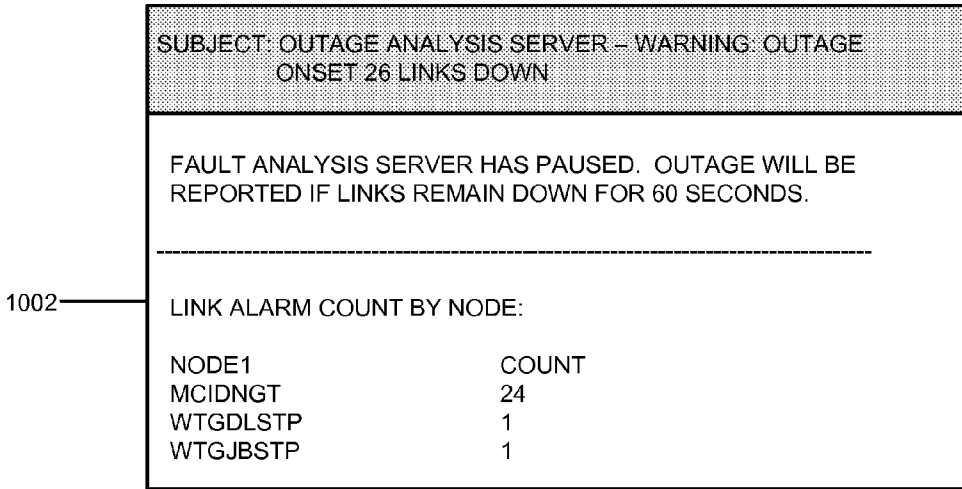


Fig. 10A

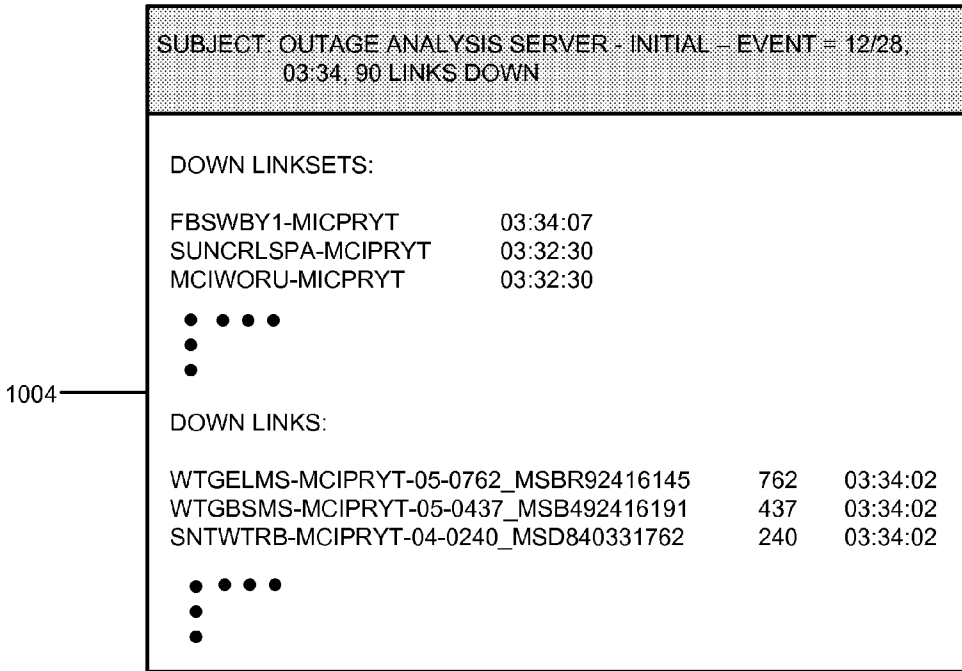


Fig. 10B

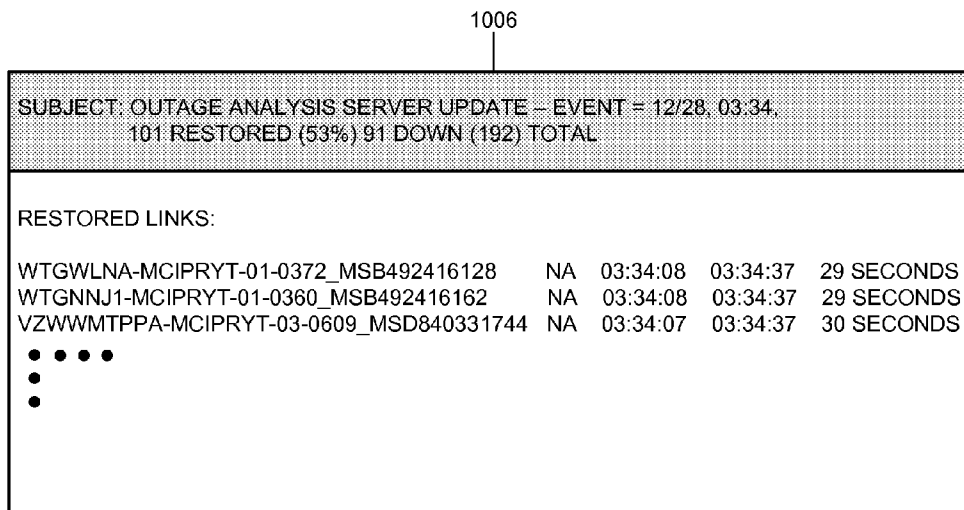


Fig. 10C

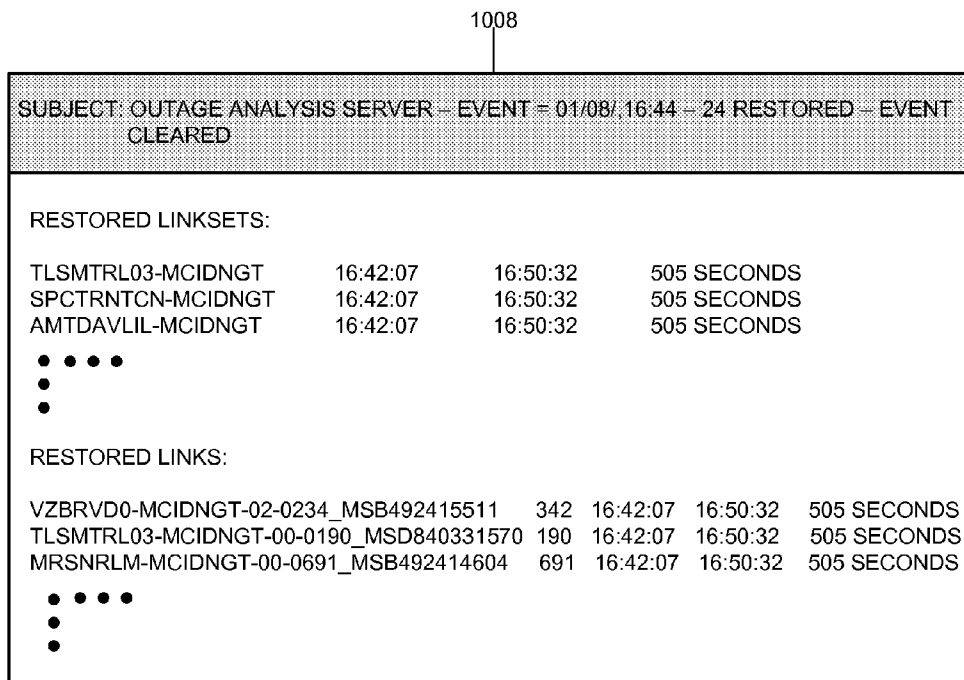


Fig. 10D

1102

OUTAGE REPORT

LINK	LINKSETS	NODES	
DOWN (TOTAL)	32	15	4
OUTAGE	0	0	0

1104

DOWN LINKS

#	D	ND1	EQ1	PC1	LK1	LINK NAME	ND2	EQ2	PC2	LK2	SLC	PROC	CIRCUIT ID
1						KGEX-TP1-N12-MCI-TP1-N12					0		
2		HAYT	STP-SSG	244-205-000	192	PBTSCRICA-MCIHAYT	SCRMCA0100W	DIGITAL DEX-STP	251-013-000	0	0	CTLK	MSD840330587
3		WRGT	STP-SSG	244-203-000	597	SNTHFRFCT-MCIWRGT	HRFRCT0301W	AT&T SS7 #2 STP	243-000-000	0	0	CTLK	MSD840331579
4						CAL-SD-SD-N10-MCI-SD1-N10					0		

1106

Fig. 11

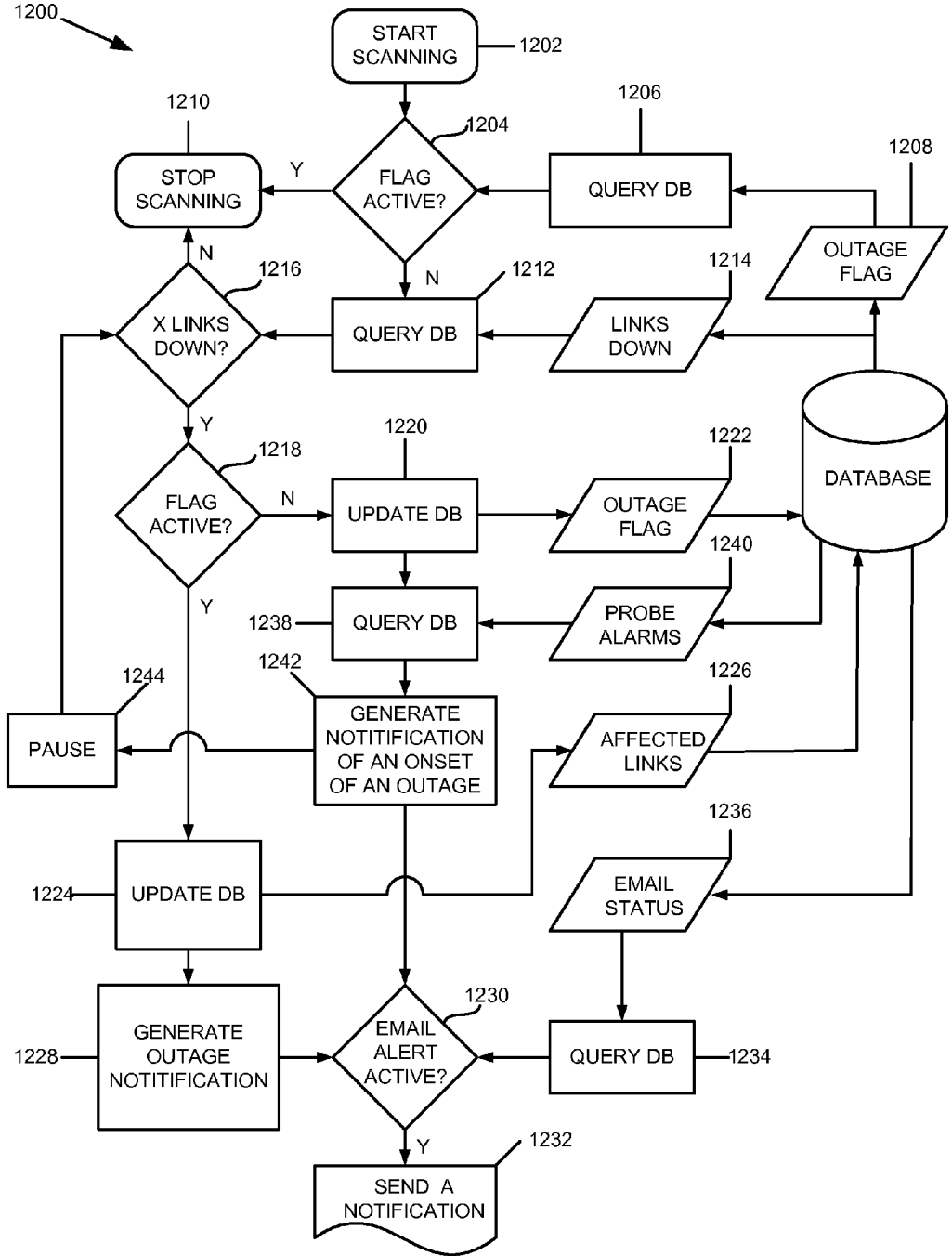


Fig. 12

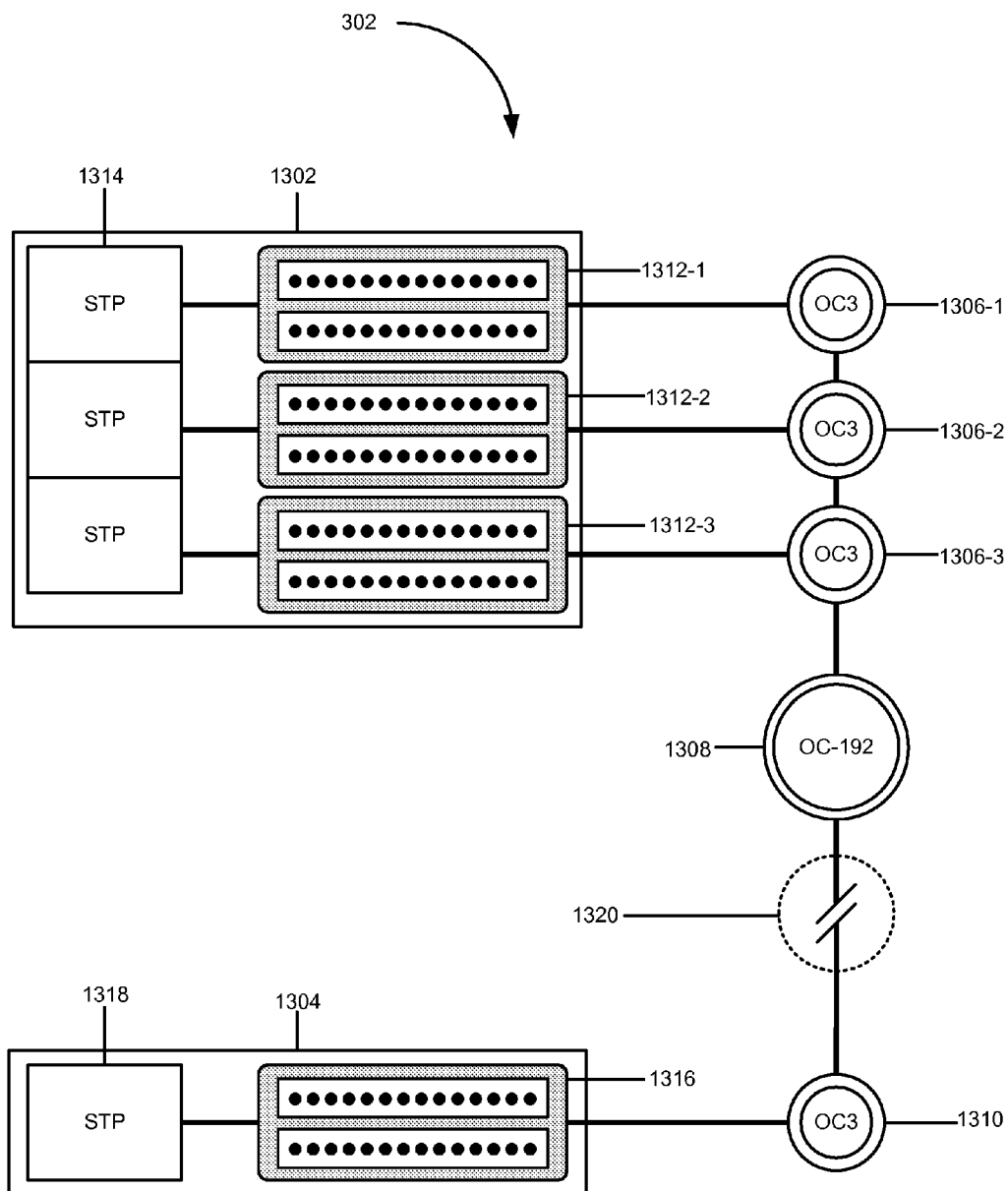


Fig. 13

	SITE	COUNT
1402 {	HAY	5
	DNJ	3

Fig. 14A

	SITE	DS3	COUNT
1404 {	HAY	DNX-88 AA	5
	DNJ	M13 ZHE	1
	DNJ	M13 ZCR	1
	DNJ	M13 ZGD	1

Fig. 14B

OUTAGE ANALYSIS SYSTEM
CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 12/055,410 filed on Mar. 26, 2008, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] When a network element that carries network traffic and/or signals malfunctions, a network monitoring system may alert a network operator about the network element. Depending on the malfunction, the network operator may either wait until the network element recovers, or may dispatch an engineer to repair or replace the network element.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0003] FIG. 1 is a block diagram of exemplary alarm records;
- [0004] FIG. 2 is a block diagram of an exemplary site table for the exemplary alarm records of FIG. 1;
- [0005] FIG. 3 is a block diagram of an exemplary network in which concepts described herein may be implemented;
- [0006] FIG. 4 is a block diagram of exemplary devices of FIG. 3;
- [0007] FIG. 5 is a functional block diagram of an exemplary outage analysis server device of FIG. 3;
- [0008] FIG. 6 is a diagram of an exemplary circuit layout record;
- [0009] FIGS. 7A through 7C are exemplary tables that summarize alarm records based on the exemplary circuit layout record of FIG. 6;
- [0010] FIG. 8 is an exemplary report of a feed-based analysis;
- [0011] FIG. 9A depicts output of a restore tracker of FIG. 5 as a web page;
- [0012] FIG. 9B is a diagram that shows a relationship between an exemplary node, linksets, and links;
- [0013] FIGS. 10A through 10D show portions of exemplary email reports about different types of events that are associated with device outages;
- [0014] FIG. 11 shows an exemplary web page that describes an outage;
- [0015] FIG. 12 is a flow diagram of an exemplary process reporting network device outages;
- [0016] FIG. 13 shows another exemplary network in which the concepts described herein may be implemented; and
- [0017] FIGS. 14A and 14B show exemplary tables that summarize alarms that are generated when devices in a network of FIG. 13 fail due to a network outage.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0018] The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. The terms “message” or “packet,” as used herein, may refer to one or more packets, datagrams, cells; fragments of one or more packets, data grams or cells; or other types of data.

[0019] In the description to follow, an outage analysis system may receive alarms about network device failures/outages, summarize and/or analyze the alarms, and provide a

report of the summary and/or analysis to a network operator, manager, and/or user. FIG. 1 is a block diagram of alarm records 100 that can be generated when a network outage occurs. As shown, alarm records 100 may include records 102-1 through 102-M (herein collectively referred to as records 102 and individually as record 102-x). As further shown, each record 102-x may include date and time fields 104 and 106 to indicate the day and time of the occurrence of a failure; a severity field 108 to indicate severity of the failure; a probe field 110 to identify the probe that has detected the failure; a link/node field 112 to identify the network element that has failed; and a failure type field 114 to identify the type of failure that is associated with the alarm record. In a different implementation, record 102-x may include fewer, additional, or different fields than those illustrated in FIG. 1.

[0020] In a large system, when an outage occurs, many network devices and/or links (e.g., tens of thousands) may fail, and flood the outage analysis system with alarms that are translated to alarm records 100 by the outage analysis system. Because the number of alarm records is large, attempting to diagnose a network problem by manually examining alarm records 100 may be difficult or impractical. In such an instance, a summary of information about the alarms may be helpful to the network operator, manager, and/or user for identifying the network problem.

[0021] FIG. 2 is a block diagram of an exemplary site table 200 that summarizes alarms. As shown, site table 200 may include records 202-1 through 202-S (herein collectively referred to as 202 and individually as record 202-x). As further shown, each record 202-x within site table 200 may include site field 204 that identifies a site at which a failure has occurred and a count field 206 that indicates the number of alarms that are generated at the site. Depending on the implementation, record 202-x may include fewer, additional, or different fields than the ones shown in FIG. 2.

[0022] Each record 202-x in site table 200 may summarize information about a number of alarms. For example, record 202-1 may indicate that over 318 alarms are generated from a site named PMM. Because site table 200 condenses information that is provided by the alarms, the network operator, manager, or user may examine site table 200 faster and more easily than they would examine alarm records 100.

[0023] In addition to summarizing alarms, the outage analysis system may perform a series of actions to determine whether there is an outage and whether the detected outage constitutes a false outage. Furthermore, the outage analysis system may maintain a timeline of events that are associated with outages (e.g., a recovery), and/or provide reports of the events via different notification schemes (e.g., email messages, updating web pages, etc.). The analysis of the outage and/or reports of the outage may be helpful for the network operator, manager, and/or user in identifying and/or resolving network problems that are associated with the outage.

[0024] FIG. 3 is a block diagram of an exemplary network 300 in which concepts described herein may be implemented. As shown, network 300 may include a service/signaling network 302 (e.g., signaling system 7 (SS7) network, an Internet Protocol (IP) network, etc.) and a control/monitoring network 304 (e.g., SS7 network, IP network, etc.), switch/gateways 306-1 through 306-3 (herein collectively referred to as switches/gateways 306 and individually as switch/gateway 306-x), devices 308-1 and 308-2, and probes 310-1 and 310-2. Depending on the implementation, network 300 may include additional, fewer, or different devices than those illus-

trated in FIG. 3. For example, network 300 may include additional switches/gateways 306, devices 308, and/or probes 310.

[0025] Service/signaling network 302 may include a public switched telephone network (PSTN), a local area network (LAN), a wireless LAN (WLAN), a wide area network (WAN), a metropolitan area network (MAN), a cellular network, the Internet, any other network, or a combination of networks.

[0026] Control/monitoring network 304 may include a LAN, a WLAN, a WAN, a MAN, a cellular network, the Internet, a PSTN, any other network, or a combination of networks. Depending on the implementation, control/monitoring network 304 and service/signaling network 302 may be implemented as part of the same network, or two different networks.

[0027] Switch/gateway 306-x may include one or more devices that provide signal entry/exit to/from service/signaling network 302. For example, in the context of SS7, switch/gateway 306 may include a service switching point (SSP) that handles incoming telephone calls. In another example, in the IP context, switch/gateway 306 may include a gateway that relays IP packets from a computer.

[0028] Devices 308 may include devices that communicate with other devices in service/signaling network 302. For example, if service/signaling network 302 is implemented as a SS7 network, device 308-x may include a telephone. If service/signaling network 302 is implemented as an IP network, device 308-x may include a personal computer, a laptop, etc.

[0029] Probes 310-1 and 310-2 may include devices for detecting device/component failures and for generating alarms when probes 310 detect the failures. For example, probe 310-1 may detect a failure on the device/link to which probe 310-1 is attached (e.g., a link between router/gateway 312-1 and another device). When probe 310-1 detects a failure of the device/link, probe 310-1 may generate an alarm. The alarm may be sent to an alarm collecting device (e.g., probe server device 314) in control/monitoring network 304.

[0030] As further shown in FIG. 3, service/signaling network 302 may include routers/gateways 312-1 through 312-4 (herein collectively referred to as routers/gateways 312 and individually as router/gateway 312-x). Although service/signaling network 302 is shown as including routers/gateways 312-1 through 312-4, depending on the implementation, service/signaling network 302 may include fewer, additional, or different devices than those illustrated in FIG. 3. For example, when service/signaling network 302 is implemented as a SS7 network, service/signaling network 302 may include voice circuits and/or service control points (SCP) (not shown) for supporting telephony.

[0031] Router/gateway 312-x may include a device for routing messages and/or packets between different points in service/signaling network 302 and/or other routers/gateways 312. Depending on the implementation of service/signaling network 302, routers/gateways 312 may include an IP packet router, a switch, a bridge, a signal transfer points (STPs), or any other device that may be used to deliver and/or relay messages or packets.

[0032] As further shown in FIG. 3, control/monitoring network 304 may include a probe server device 314, a database server device 316 and an outage analysis server device 318. Depending on the implementation, control/monitoring network 304 may include fewer, additional, or different devices

than those illustrated in FIG. 3, such as a central device for collecting information about different network topology. In one implementation, functionalities of database server device 314, probe server device 316, and/or outage analysis server device 318 may be combined in a single device, or alternatively, may be distributed over additional devices.

[0033] Probe server device 314 may receive alarms that are generated at probes 310 and may provide the alarms to database server device 316 and/or outage analysis server device 318. Database server device 316 may store and/or dispense information about alarms and/or network devices in one or more databases. For example, database server device 316 may store information about alarms that are received by probe server device 314, and may dispense information about the alarms to outage analysis server device 318. In another example, database server device 316 may store circuit layout records (CLRs) (e.g., a list of devices that form a network circuit) and provide outage analysis server device 318 with the CLRs.

[0034] Outage analysis server device 318 may analyze alarm-related information (e.g., CLRs, alarm records, etc.) that is stored in database server device 316, summarize results of the analysis in different formats, and provide reports of the summaries to network operators, managers, etc. In analyzing the alarm-related information that is stored in database server device 316, outage analysis server device 318 may correlate different data, detect outages, detect probe failures, and/or track device restorations after outages. In providing the reports, outage analysis server device 318 may post the reports as web pages, and/or send reports as email messages and/or other types of messages (e.g., instant messages).

[0035] FIG. 4 is a block diagram of exemplary devices of FIG. 3. Device 400 may represent one or more of devices in FIG. 3, such as switch/gateway 310-x, router/gateway 312-x, probe server device 314, database server device 316, and/or outage analysis server device 318. As shown, device 400 may include a processor 402, a memory 404, input/output components 406, a network interface 408, and a communication path 410. In different implementations, device 400 may include additional, fewer, or different components than the ones illustrated in FIG. 4. For example, device 400 may include additional line interfaces, such as interfaces for receiving and forwarding messages (e.g., packets, SS7 messages, etc.).

[0036] Processor 402 may include a processor, a microprocessor, an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), and/or other processing logic capable of controlling device 400. Memory 404 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. Memory 404 may also include storage devices, such as a floppy disk, CD ROM, CD read/write (R/W) disc, and/or flash memory, as well as other types of storage devices.

[0037] Input/output components 406 may include a display screen, a keyboard, a mouse, a speaker, a microphone, a Digital Video Disk (DVD) writer, a DVD reader, Universal Serial Bus (USB) lines, and/or other types of components for converting physical events or phenomena to and/or from digital signals that pertain to device 400.

[0038] Network interface 408 may include any transceiver-like mechanism that enables device 400 to communicate with other devices and/or systems. For example, network interface 408 may include mechanisms for communicating via a net-

work, such as the Internet, a terrestrial wireless network (e.g., a WLAN), a satellite-based network, a wireless personal area network (WPAN), etc. Additionally or alternatively, network interface **408** may include a modem, an Ethernet interface to a LAN, and/or an interface/connection for connecting device **400** to other devices.

[0039] Communication path **410** may provide an interface through which components of network device **400** can communicate with one another.

[0040] FIG. 5 is a functional block diagram of exemplary outage analysis server device **318**. As shown, outage analysis server device **318** may include a correlation engine **502**, an outage detector **504**, a restore tracker **506**, an outage notification system **508**, a web server **510**, and email client/server **512**. Although not illustrated in FIG. 5, outage analysis server device **318** may include additional functional components, such as the components included in device **400**, an operating system (e.g., Linux, Windows, etc.), an application (e.g., an instant messenger client), etc.

[0041] Correlation engine **502** may correlate alarm-related information that is stored in database server device **314** and summarize the information. In one implementation, correlation engine **502** may correlate circuit layout records (CLRs) that are stored in database server device **316**, and produce summaries of the CLRs as tables.

[0042] FIG. 6 shows an exemplary CLR **600** in database server device **316**. As shown, CLR **600** may include lines **602-1** through **602-N** (herein collectively referred to as lines **602** and individually as line **602-x**). As further shown, each line **602-x** may include a site identifier (ID) field **604** and an equipment specification field **606**. Line **602-x** may include other fields, although they are not illustrated in FIG. 6. Site ID field **604** may provide the name of a site (e.g., a datacenter) that hosts a particular network element. Equipment specification field **606** may identify a network element (e.g., a cross-connect) and/or provide a description of the network element.

[0043] When an outage occurs, correlation engine **502** may scan CLRs that correspond to failed network elements in network **302**. Correlation engine **502** may scan each CLR by splitting CLR **600** into lines **602**, and partitioning each line **602-x** into segments or portions. Furthermore, by parsing each of the segments, correlation engine **502** may count the number of times that each site or each link occurs in lines **602**. Correlation engine **502** may tally the number of occurrences for each site and each link in the CLRs and generate tables that summarize results of the tally.

[0044] For example, correlation engine **502** may partition each line **602-x** into segments, scan the segments, and count the number of occurrences for each of sites AST, MEJ, and WYV (e.g., 3 times for AST, 2 times for MEJ, 3 times for WYV, and once for NOR). Correlation engine **502** may aggregate the results of such counts over many CLRs into a site table that summarizes the information included in the CLRs.

[0045] FIG. 7A illustrates an exemplary site table **700**. As shown, site table **700** may include records **702-1** through **702-P** (hereinafter collectively referred to as records **702** and individually as record **702-x**). As further shown, each record **702-x** may include a site field **704** that identifies the site at which alarms due to the outage are generated and a count field **706** that indicates the number of alarms that are generated due to device/component failures at the site. For example, according to record **702-1**, 318 alarms are generated at site AST.

[0046] In scanning the CLRs, in addition to counting the number of occurrences of each site, correlation engine **502** may also count the number of occurrences of each of the failed links. Correlation engine **502** may tally the number of occurrences of each link of a given type (e.g., a Digital Signal Level 1 (DS1) link for carrying 24 DS0 voice channels at 1.544 megabits per second (Mbps), a Digital Signal Level 3 (DS3) link for carrying data at 44.736 Mbps, etc.) in the CLRs and generate a link table that summarizes the results of the tally.

[0047] FIG. 7B illustrates an exemplary link table **708** for DS1 links. As shown, link table **708** may include records **710-1** through **710-Q** (hereinafter collectively referred to as records **710** and individually as record **710-x**). As further shown, each record **710-x** may include a site field **712** that identifies the site at which a failed link is located, a DS1 field **714** that identifies the link associated with record **710-x**, and a count field **716** that indicates the number of alarms that are generated by the link. For example, according to record **710-1**, 9 alarms are generated by link DXC-1/0 AA DS1 773, which is located at site NOR.

[0048] FIG. 7C illustrates another exemplary link table **718** for DS3 links. As shown, link table **718** may include records **720-1** through **720-R** (hereinafter collectively referred to as records **720** and individually as record **720-x**). As further shown, each record **720-x** may include a site field **722** that identifies the site at which a failed link is located, a DS3 field **724** that identifies the link associated with record **720-x**, and a count field **726** that indicates the number of alarms that are generated by the link. For example, according to record **720-1**, 12 alarms are generated by link M13-ZA V.

[0049] Returning to FIG. 5, outage detector **504** may use a decision sequence to analyze a potential outage. In one implementation, outage detector **504** may determine if a number of failed links or unavailable bandwidth has reached a threshold (e.g., 25 links) in a given span of time (e.g., 60 seconds). The threshold may be selected such that when the number of failures or the unavailable bandwidth reaches the threshold, outage detector **504** may conclude that an outage has occurred. In one implementation, the threshold may be set to 25 DS0 or links, which is greater than a Trunk (T1) (1.544 Mbps) worth of bandwidth. Setting such a threshold may prevent outage detector **504** from triggering on false outages (e.g., bouncing devices).

[0050] When outage detector **504** detects that the number of failed links or unavailable bandwidth has reached the threshold, outage detector **504** may determine whether an outage flag is set. The outage flag, which can be stored in memory **404**, may indicate whether there is currently an outage. If the outage flag indicates that there is no outage, outage detector **504** may pause for a particular amount of time. By pausing, outage detector **504** may allow all pending alarms to be received and detected by outage detector **504**. When outage detector **504** resumes, outage detector **504** may reevaluate whether there is an outage based on the number of alarms.

[0051] In addition to determining the outage, outage detector **504** may perform a feed-based alarm analysis, to help the network operator, manager, or user determine whether the detected outage is a false outage. In some instances, an alarm-feed (e.g., a system that feeds alarms, probe **310-1**, probe **310-2**, etc.) may fail. These types of failures can sometimes generate false alarms, and, consequently, cause outage detector **504** to signal a false outage. To determine if the detected

outage can be a false outage, outage detector **504** may examine specific types of alarms—alarms that indicate if the probe's alarm feed has failed.

[0052] FIG. **8** is an exemplary report **800** of the feed-based alarm analysis. As shown, report **800** may include a system status portion **802**, a summary of alarms portion **804**, and a summary of alarm-feed alarms portion **806**. Depending on the implementation, report **800** may include additional, fewer, or different portions. Status portion **802** may indicate the current operational status of correlation engine **502**, outage detector **504**, restore tracker **506**, and/or outage notification system **508**. Summary of alarms portion **804** may indicate a number of alarms that are generated due to link failures at particular nodes. Summary of alarm-feed alarms portion **806** may list alarms that are generated for a particular alarm-feed. For example, in FIG. **8**, summary of alarm-feed alarms portion **806** may indicate that nine alarms have been generated due to alarm-feed failures.

[0053] Returning to FIG. **5**, restore tracker **506** may maintain and provide a timeline for links that are restored after an outage. FIG. **9A** shows output of restore tracker **506** as a web page. The web page may be generated upon an occurrence of an event (e.g., an outage, a restore, etc.). As shown, a restore timeline **900** may include a link summary table **902** and restore tables **904** and **906**. Depending on the implementation, restore timeline **900** may include additional, fewer, or different components than those illustrated in FIG. **9A**.

[0054] Link summary table **902** may provide numbers of links, linksets, and/or nodes that are on-net (e.g., on or in an internal or a designated network) or off-net (e.g., outside of the internal/designated network). FIG. **9B** is a diagram that illustrates a relationship between a node **908**, linksets **910-1** through **910-3**, and links **912-1** through **912-12**. As shown, node **908** may represent the highest level of control (e.g., a STP, a switch, etc.). Each of linksets **910-1** through **910-3** may include a collection of links that are connected to node **908**. Although FIG. **1** shows three linksets **910-1** through **910-3** and 12 links **912-1** through **912-12**, an actual node may be interconnected by fewer or more than 3 linksets and/or 12 links. In addition, the number of links in different linksets may or may not be the same.

[0055] Each of restore tables **904** and **906** may include a snap shot of the summary of states of links, linksets, and/or nodes. Furthermore, each of restore tables **904** and **906** may include numbers of link, linksets, and/or nodes that are restored and/or are down. Additionally, restore tables **904** and **906** may also indicate when events (e.g., an occurrence of an outage, etc.) may have been cleared (e.g., an outage no longer exists). Restore tables **904** and **906** may be stored in database server device **316** and retrieved upon demand via, for example, web server **510**.

[0056] Returning to FIG. **5**, outage notification system **508** may provide email reports that are related to outages to the network operators, managers, users, etc. and/or update the databases for web page updates. In providing notifications of events, outage notification system **508** may receive information about different events from other components of FIG. **5**, such as correlation engine **502**, outage detector **504**, etc. In addition, depending on the implementation, outage notification system **508** may provide other types of notifications, including an instant message, a voice mail, etc.

[0057] FIG. **10A** shows a portion of email report **1002** that may be provided by outage notification system **508**. As shown, email report **1002** may indicate an onset of an outage.

Email report **1002** may provide information that is related to the outage, such as number of alarms that are generated at different nodes. FIG. **10B** shows a portion of another email report **1004**. As shown, email report **1004** may provide information that pertains to initial stages of the outage, such as links that are down, times at which the links went down, linksets or nodes that are down, etc. FIG. **10C** shows a portion of yet another email report **1006** that may provide an update for an existing event. As shown, email report **1006** may indicate when the links are restored. FIG. **10D** shows a portion of still another email report **1008** that may indicate when an event has been cleared. As shown, email report **1008** may include a list of restored linksets, an amount of time that has elapsed before alarms for each linkset has been cleared, a list of links, etc.

[0058] FIG. **11** shows a web page report **1102** that may be provided by outage notification system **508**. As shown, web page report **1102** may include a summary table **1104** and a detailed link table **1106**. Summary table **1104** may provide a summary of links, linksets, and/or nodes that are down and/or are suffering from an outage. Detailed link table **1106** may include detailed information about links that are down. As shown in FIG. **11**, some of the fields of detailed link table **1106** may include an index field **1108** that references a link by an index; a node field **1110** that provides the name of a site at one end of a link; an equipment field **1112** that identifies an equipment at the one end of the link; a point code field **1114** that carries a SS7 code for designating a logical network location of the equipment (e.g., network address); a link name field **1116** for identifying the link; etc.

[0059] Although not illustrated in FIG. **11**, web page report **1102** may include other types of information, such as outage updates, clearing of an outage, etc. A view of web page report **1102** may be customizable for those who have access to web page report **1102**.

[0060] Referring back to FIG. **5**, web server **510** may include an application for receiving hypertext transfer protocol (HTTP) requests and/or for providing HTTP responses to clients (e.g., browsers). In one implementation, web server **510** may provide static and/or dynamic web pages, programs, etc., in accordance with the output of outage notification system **508**. For instance, web server **510** may provide web page report **1102** (FIG. **11**) in accordance with outage information from outage notification system **508**.

[0061] Email client/server **512** may include software components for composing and/or sending email messages in accordance with output of outage notification system **508**. For example, email client/server **512** may send email messages whose portions are illustrated in FIGS. **10A** through **10D**.

[0062] The above paragraphs describe system elements that are related to devices and/or components for analyzing failures/outages of network devices. FIG. **12** is a flow diagram of a process **1200** that is capable of being performed by one or more of these devices and/or components.

[0063] As shown in FIG. **12**, process **1200** may begin at block **1202**, where an outage flag may start being scanned (block **1202**). For example, outage analysis server device **318** may begin to scan the outage flag, which may be stored in a database (e.g., a database in database server device **316**), to detect whether there is currently an outage.

[0064] It may be determined if the outage flag is active (block **1204**). To determine whether the outage flag is active,

outage analysis server device **318** may query the database, which may respond with the outage flag (blocks **1206** and **1208**).

[0065] At block **1204**, if the outage flag is active, the outage flag may indicate that there is an outage, and process **1200** may proceed to block **1210**, where the outage flag may stop being scanned (block **1210**). If the outage flag is inactive, process **1200** may proceed to block **1212**.

[0066] One or more databases may be queried for links that are down (blocks **1212** and **1214**). For example, outage analysis server device **318** may query the databases. Based on the query, at block **1216**, it may be determined if more than X (e.g., a threshold number, such as 25) links are down (block **1216**). If more than X links are not down, process **1200** may proceed to block **1210** and stop scanning the outage flag.

[0067] If more than X links are down, it may be determined if the outage flag is active (block **1218**). If the outage flag is not active, the outage flag in the database may be updated (blocks **1220** and **1222**). If the outage flag is active, the database may be updated so that the alarm records that are associated with the affected links are marked (blocks **1224** and **1226**).

[0068] At block **1228**, a notification of an outage may be generated (block **1228**). In one implementation, when outage analysis server device **318** generates the notification, outage analysis server device **318** may update relevant information in the database, such that when web server **510** is accessed via a browser, a web page that shows the outage status may be displayed on the browser.

[0069] If an email alert is active (e.g., information in the database indicates outage notification system **508** is to send email messages when an event associated with the outage occurs) (block **1230**), a notification about the outage in the form of an email message may be sent (block **1232**). In determining whether the email alert is active at block **1230**, the database may be queried at block **1234**, and email status may be fetched (e.g., whether an email message has been sent) (block **1236**).

[0070] Returning to block **1220**, after updating the database, the database may be queried to obtain alarms that may be related to probe failures (block **1238**). In response, alarms that indicate whether probes **310** have failed may be provided (block **1240**).

[0071] A notification of an onset of the outage may be generated (block **1242**). As discussed previously with reference to FIG. **8**, the probe alarms (e.g., alarm-feed alarms) may be used to identify or suggest a false positive outage.

[0072] Process **1200** may proceed to block **1244**, where process **1200** may pause for a particular amount of time (e.g., 1 minute) to allow pending alarms that are associated with the outage to arrive (block **1244**). After the pause, process **1200** may proceed to block **1216**.

[0073] In addition, process **1200** may proceed to block **1230** to determine if the email alert is active. If the email alert is active, a notification (e.g., an onset notification) about the outage may be sent in the form of an email message (block **1232**).

[0074] In process **1200**, depending on the implementation, outage analysis server device **318** may perform correlations of CLRs at different blocks. For example, in one implementation, outage analysis server device **318** may perform a correlation analysis to produce summaries (e.g., site table **700**,

link table **708**, link table **718**, etc.) of alarms at block **1228**, so that the summaries may be sent with the email messages at block **1232**.

[0075] The following example, with reference to FIGS. **13**, **14A** and **14B**, illustrates a process for analyzing an outage. The example is consistent with exemplary process **1200** described above with reference to FIG. **12**.

[0076] For the example, assume that service/signaling network **302** includes a site **1302**, a site **1304**, an optical carrier level 3 (OC-3) **1306-1**, an OC-3 **1306-2**, an OC-3 **1306-3**, OC-192 **1308**, and OC-3 **1310** that are interconnected as illustrated in FIG. **13**. In addition, assume that probes are located at various points in service/signaling network **302**, that the threshold for detecting an outage is 25 DS0 links or a bandwidth equivalent of 25 DS0 links. Further, assume that a network engineer trips over a fiber optics line at point **1320** and causes the fiber optics line to become disconnected from OC-3 **1308** and OC-3 **1310**.

[0077] In the example, outage analysis server device **318** begins scanning for an outage flag that is stored in a database at database server device **316**. The flag is inactive, and outage analysis server device **318** queries the database for a list of alarm records for links that are down. The database shows that more than 25 DS0 links worth of bandwidth is unavailable due to device failures.

[0078] Based on the list of alarm records, outage analysis server device **318** obtains CLRs that are associated with the failed links and performs a correlation analysis. Outage analysis server device **318** produces a site table and a link table. FIG. **14A** shows the site table **1402**. As shown, site HAY generates 5 alarms and site DNJ generates 3 alarms. FIG. **14B** shows a link table for DS3 links. As shown, link DNX-88AA at site HAY generates 5 alarms and each of links M13 ZHE, M13 ZCR, and M13 ZGD generates 1 alarm. Because there are no DS1 links at HAY or DNJ, outage analysis server device **318** does not generate a link table for DS1 links.

[0079] Outage analysis server device **318** examines the outage flag again, and updates the database to indicate that the outage flag is active. Furthermore, once outage analysis server device **318** determines that there is a potential outage based the amount of unavailable bandwidth, outage analysis server device **318** determines if a probe has failed, by requesting a list of alarm-feed alarms for the probes.

[0080] Outage analysis server device **318** receives no alarm-feed alarms for the probes, and generates a notification of an onset of an outage. Because an email alert is active, the notification is sent to a network operator as an email message. The email message may include results of the correlation analysis, site table **1402**, and link table **1404**.

[0081] In addition, outage analysis server device **318** pauses, in order for other pending alarms that are associated with the detected outage to be collected at database server device **316**. Meanwhile, the network engineer who has tripped over the fiber optics cable notices the unplugged fiber optics cable, reconnects the disconnected fiber optics cable, and causes devices in service/signaling network **302** to be restored. Outage analysis server device **318** stops scanning the outage flag when outage analysis server device **318** determines that there are less than 25 DS0 links worth of bandwidth that is unavailable.

[0082] Outage analysis server device **318** prepares additional email alerts (e.g., an update report, etc.) and sends them to the network operator. In addition, outage analysis server

device 318 updates the database so that when a user accesses web server 510 via a remote browser, web server 510 may provide other notifications (e.g., table 1106) and/or a timeline of outage restores (e.g., restore table 904).

[0083] In the above example, outage analysis server 318 receives alarms about network device failures/outages, summarizes and/or analyzes the alarms, and provides a report of the summary and/or analysis to the network operator. In a system that is much larger than that illustrated in FIG. 13, when an outage occurs, many network devices (e.g., tens of thousands) may fail, and flood the outage analysis system with alarms that are translated to alarm records. In such instances, because the number of alarm records is large, attempting to diagnose a network problem by manually examining the alarm records may be difficult or impractical. In such a case, a summary of information about the alarms may be helpful to the network operator for identifying the network problem.

[0084] In addition to summarizing the alarms, outage analysis server device 318 may perform a series of actions to determine whether there is an outage and whether the detected outage is a false outage. Outage analysis server device 318 may also maintain a timeline of events that are associated with the outage, and/or provide reports of the outage via different notification schemes (e.g., email messages, updating web pages, etc.). The analysis and/or reports of the outage may be helpful for the network operator, manager, and/or user in identifying and/or resolving network problems that are associated with the outage.

[0085] The foregoing description of implementations provides illustration, but is not intended to be exhaustive or to limit the implementations to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of the teachings.

[0086] For example, while a series of blocks has been described with regard to an exemplary process illustrated in FIG. 12, the order of the blocks may be modified in other implementations. In addition, non-dependent blocks may be performed in parallel to other blocks.

[0087] 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.

[0088] 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 integrated circuit, or a field programmable gate array, software, or a combination of hardware and software.

[0089] Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the invention. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

[0090] No element, act, 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 article “a” is intended to include one or more items. Where one item is intended, the term “one” or similar language is used. 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 method comprising:
 - receiving alarms identifying failures of network elements;
 - creating a site table that includes a list of sites at which the alarms are generated and a number of alarms for each of the sites;
 - determining whether an outage has occurred based on the alarms;
 - analyzing whether the outage is a false outage based on a failure of a probe that generates the alarms; and
 - providing a notification that includes the site table, an indication of whether the outage has occurred, or an indication whether the outage is a false outage.
2. The method of claim 1, further comprising:
 - creating a link table that includes a list of links at which the alarms are generated and a number of alarms for each of the links.
3. The method of claim 2, where creating the site table includes:
 - dividing a circuit layout record into lines;
 - partitioning each of the lines into segments; and
 - parsing each of the segments to identify an occurrence of one of the sites within the segment.
4. The method of claim 2, where creating the link table includes:
 - counting a number of occurrences of a link in a circuit layout record.
5. The method of claim 1, determining whether the outage has occurred includes:
 - concluding that the outage has occurred when the alarms indicate unavailability of a particular number of links or a particular amount of bandwidth.
6. The method of claim 1, determining whether the outage has occurred includes:
 - updating a flag in a database to indicate that the outage has occurred when a particular amount of bandwidth is unavailable due to failures of the network elements.
7. The method of claim 1, further comprising:
 - waiting for a particular amount of time after determining that the outage has occurred for additional alarms to be received.
8. The method of claim 1, where analyzing whether the outage is a false outage includes:
 - receiving alarms associated with the probe; and
 - determining whether the alarms associated with the probe indicates that the probe has failed.
9. The method of claim 1, where providing the notification includes at least one of:
 - updating a database that supplies information for generating a web page that displays an outage status; or
 - sending an email message about a status of the outage.
10. The method of claim 9, where sending the email message includes one of:
 - sending an email message about an onset of the outage; or
 - sending an email message about restoration of the network elements.
11. The method of claim 1, where providing the notification includes:

providing a web page that shows a timeline of events that are associated with the outage.

12. A device comprising:

a processor to:

- receive alarms that identify failures of network elements;
- determine whether an outage has occurred based on the alarms;
- create a link table that includes a list of links at which the alarms are generated and a number of alarms for each of the links;
- determine whether the outage is a false outage based on whether an alarm-feed that generated the alarms has failed; and
- store information regarding whether the outage has occurred.

13. The device of claim **12**, where the network elements include at least one of:

- a digital signal level link;
- an optical carrier level link; or
- a trunk level link.

14. The device of claim **12**, where the network elements include at least one of:

- a signaling system 7 (SS7) network element; or
- an Internet Protocol (IP) network element.

15. The device of claim **12**, where the processor is further configured to:

- correlate information provided in circuit layout records to produce a site table that summarizes information provided by the alarms.

16. The device of claim **15**, where the site table includes: a list of sites at which the alarms are generated and a number of alarms generated at each of the sites.

17. The device of claim **12**, where the processor is further configured to:

- send an email message about the outage.

18. The device of claim **17**, where the email message includes:

- information about an onset of the outage; or
- information about restoration of one of the network elements.

19. The device of claim **12**, where the processor is further configured to:

- receive a browser request for an operational status of the network elements;
- respond with information about the operational status of the network elements when the processor receives browser requests for information about the outage.

20. A computer-readable medium comprising computer-executable instructions, the computer-executable instructions comprising:

- instructions for querying a database for alarms that indicate failures of network elements;
- instructions for summarizing circuit layout records as tables;
- instructions for determining whether an outage has occurred based on a response from the database to the query; and
- instructions for updating a status of the outage in the database and for sending email reports that include the tables.

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