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Bialk et al.

(54) METHOD AND SYSTEM FOR GENERATING GEOGRAPHIC VISUAL DISPLAYS OF STATUS AND CONFIGURATION INCLUDING ASSIGNED CAPACITY OF HYBRID-FIBER COAX NETWORK ELEMENTS

(75) Inventors: **Harvey R. Bialk**, Littleton, CO (US); **Jyoti A. Kulkarni**, Arapohoe County, CO (US); **Paul E. Schauer**, Douglas County, CO (US)

Correspondence Address:
AT & T Legal Department - BK
Attention Patent Docketing
Room 2A-207, One AT & T Way
Bedminster, NJ 07921 (US)

(73) Assignee: **AT&T INTELLECTUAL PROPERTY II, L.P.**, Reno, NV (US)

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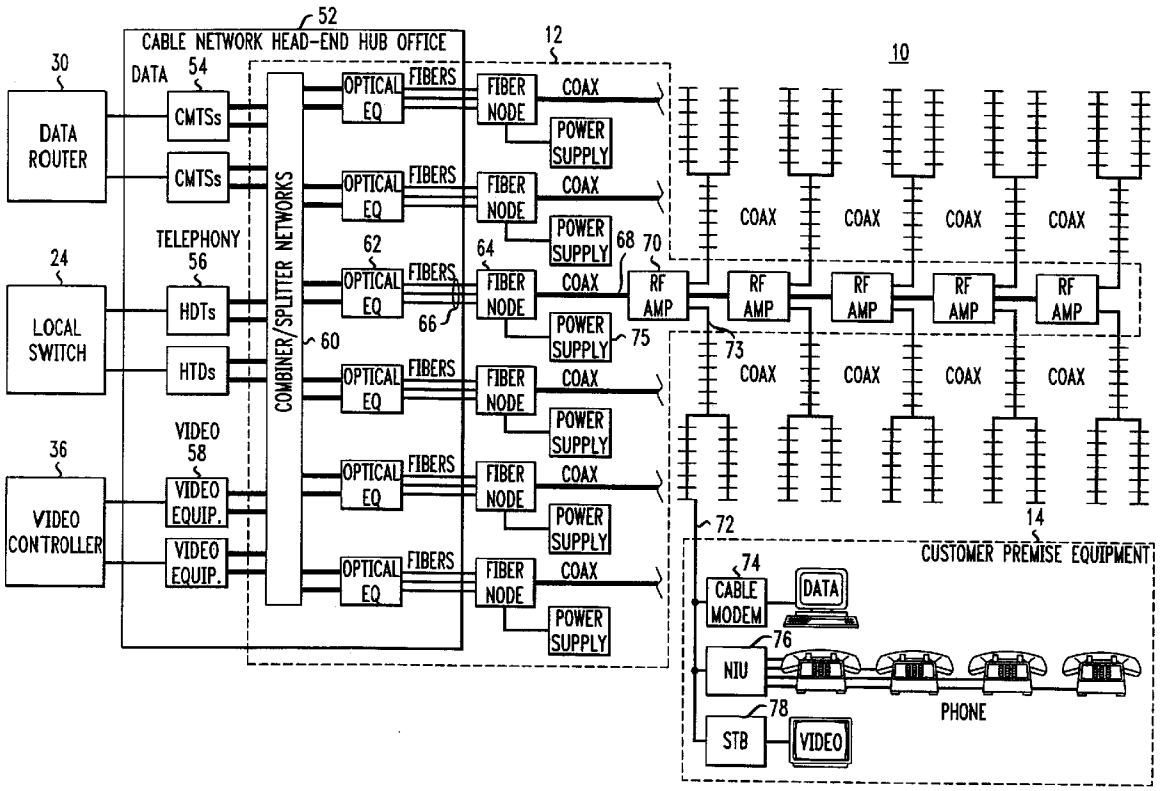
(52) **U.S. Cl.** **379/32.04**

(57) **ABSTRACT**

A system includes a hybrid fiber coax (HFC) network having network elements operable for communicating telephony, data, and video signals with customer-premises equipment (CPE) of subscribers. The system includes a manager for monitoring status and the configuration including the assigned capacity of the network elements and for generating alarm data indicative of improper status or configuration of the network elements. The system includes a database for storing data indicative of the status and the configuration of the network elements and for storing data indicative of physical and logical connections between the network elements and the CPE. The system includes an alarm visualization tool operable with the manager and the database for generating visual displays of the status and configuration including the assigned capacity of the network elements overlaid with the alarm data and the stored data indicative of the physical and logical connections between the network elements and the CPE.



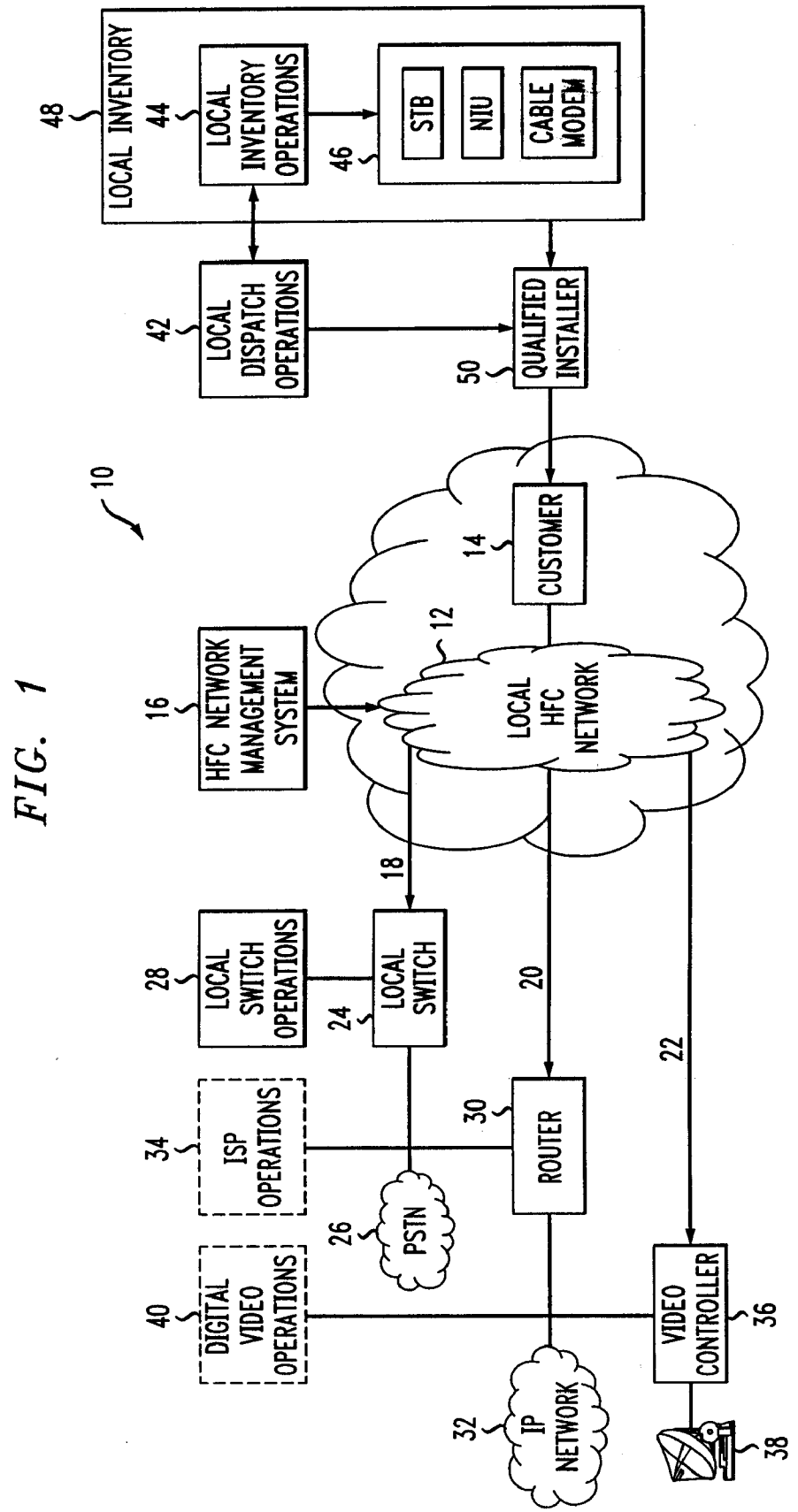
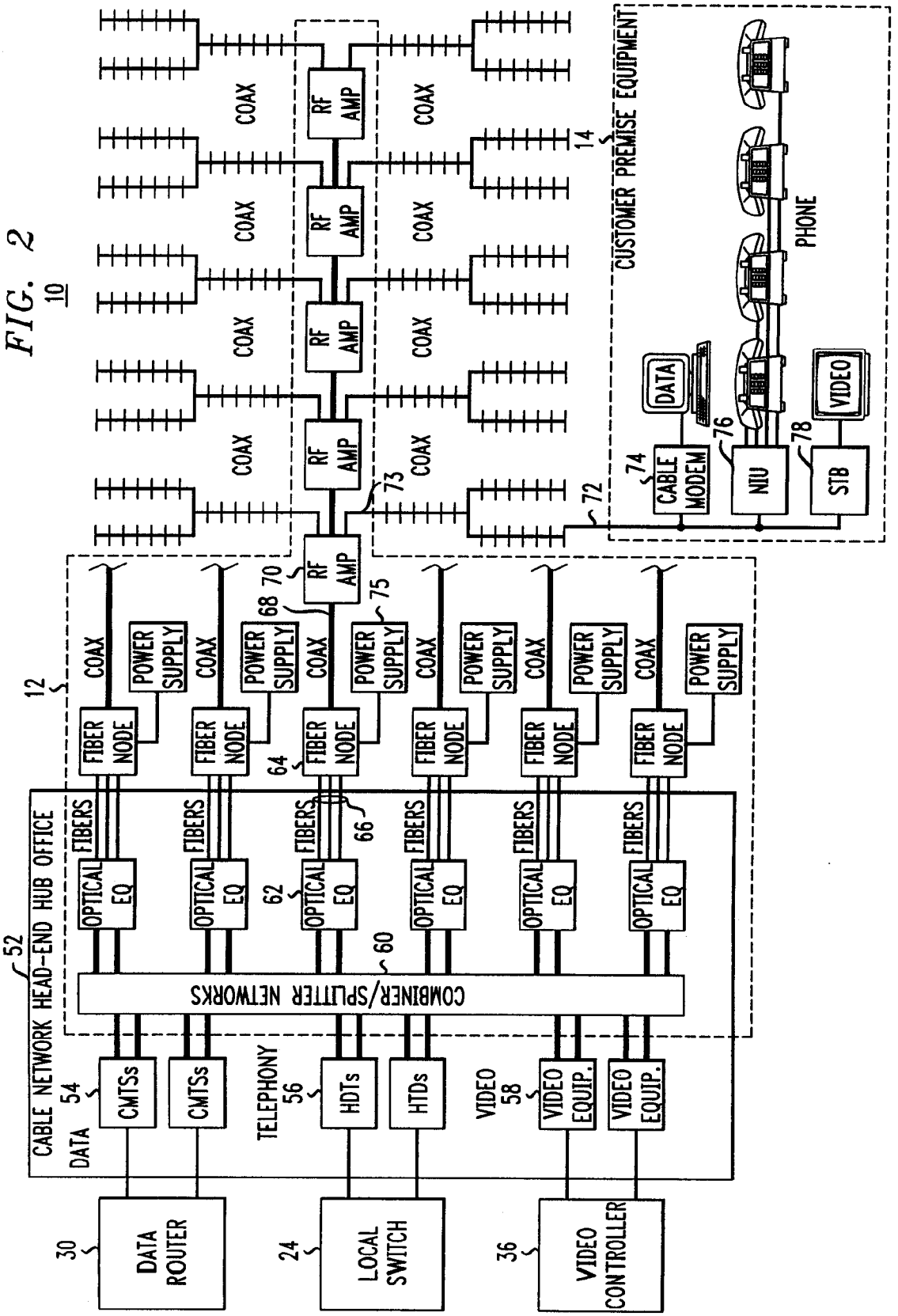

10
48
LOCAL INVENTORY
44
LOCAL INVENTORY OPERATIONS
46
STB
NIU
CABLE MODEM
42
LOCAL DISPATCH OPERATIONS
50
QUALIFIED INSTALLER
14
CUSTOMER
12
LOCAL HFC NETWORK
16
HFC NETWORK MANAGEMENT SYSTEM
18
28
LOCAL SWITCH OPERATIONS
24
LOCAL SWITCH
20
22
34
ISP OPERATIONS
30
ROUTER
26
PSTN
40
DIGITAL VIDEO OPERATIONS
32
IP NETWORK
VIDEO CONTROLLER
36
38

FIG. 1

FIG. 2


10
12
14
52
54
56
58
60
62
64
66
68
70
72
73
74
75
76
78
CABLE NETWORK HEAD-END HUB OFFICE
DATA
TELEPHONY
VIDEO
CMTSs
HDTs
HTDs
VIDEO EQUIP.
COMBINER/SPLITTER NETWORKS
OPTICAL EQ
FIBERS
FIBER NODE
POWER SUPPLY
COAX
RF AMP
DATA ROUTER
LOCAL SWITCH
VIDEO CONTROLLER
30
24
36
CUSTOMER PREMISE EQUIPMENT
CABLE MODEM
NIU
STB
DATA
PHONE
VIDEO

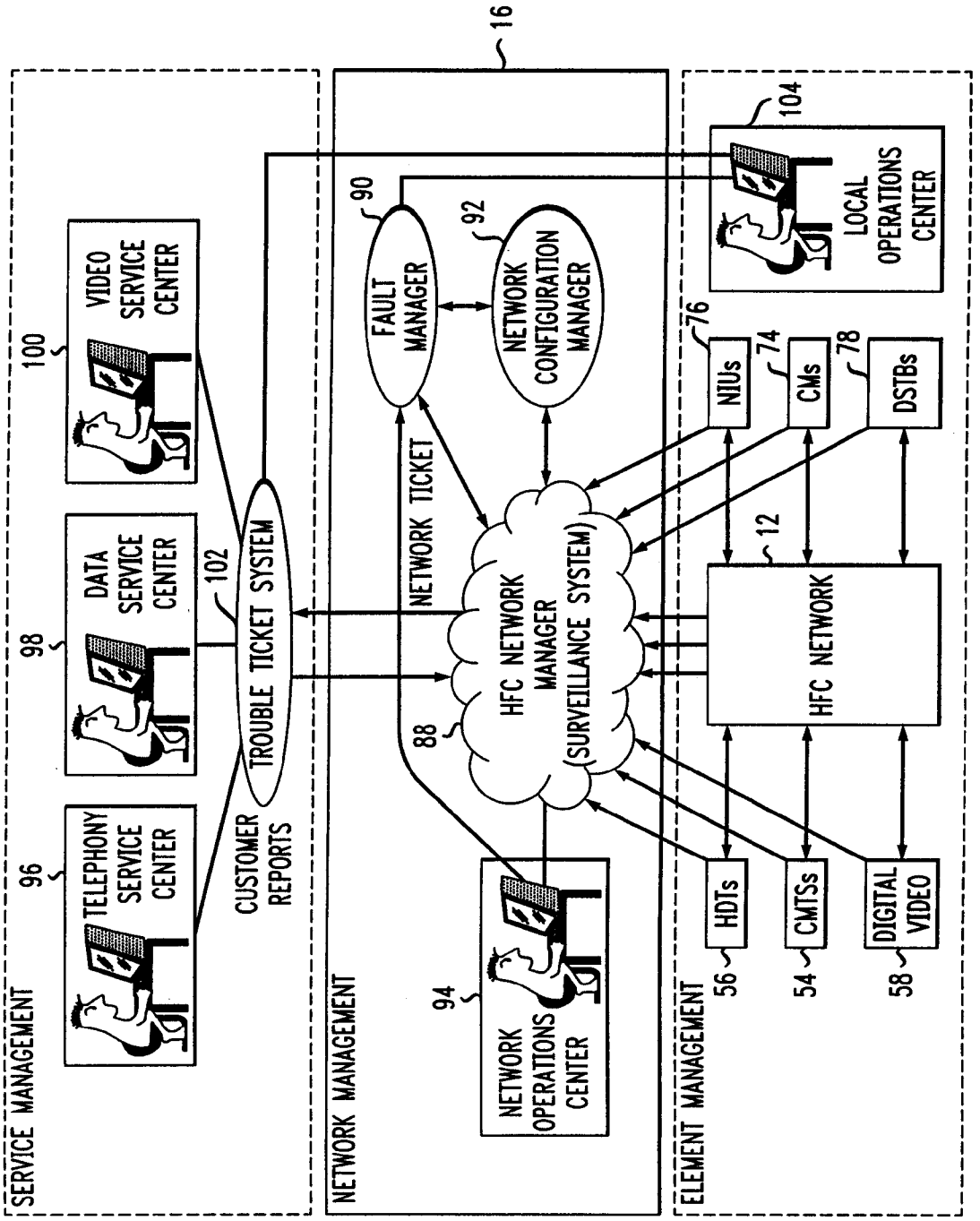

16
SERVICE MANAGEMENT
NETWORK MANAGEMENT
ELEMENT MANAGEMENT
86
84
82
VIDEO SERVICE CENTER
100
DATA SERVICE CENTER
98
TELEPHONY SERVICE CENTER
96
102
TROUBLE TICKET SYSTEM
CUSTOMER REPORTS
FAULT MANAGER
90
NETWORK CONFIGURATION MANAGER
92
NETWORK TICKET
HFC NETWORK MANAGER (SURVEILLANCE SYSTEM)
88
NETWORK OPERATIONS CENTER
94
LOCAL OPERATIONS CENTER
104
NIUs
76
CMs
74
DSTBs
78
12
HFC NETWORK
HDTs
56
CMTSs
54
DIGITAL VIDEO
58

FIG. 3

80

FIG. 4

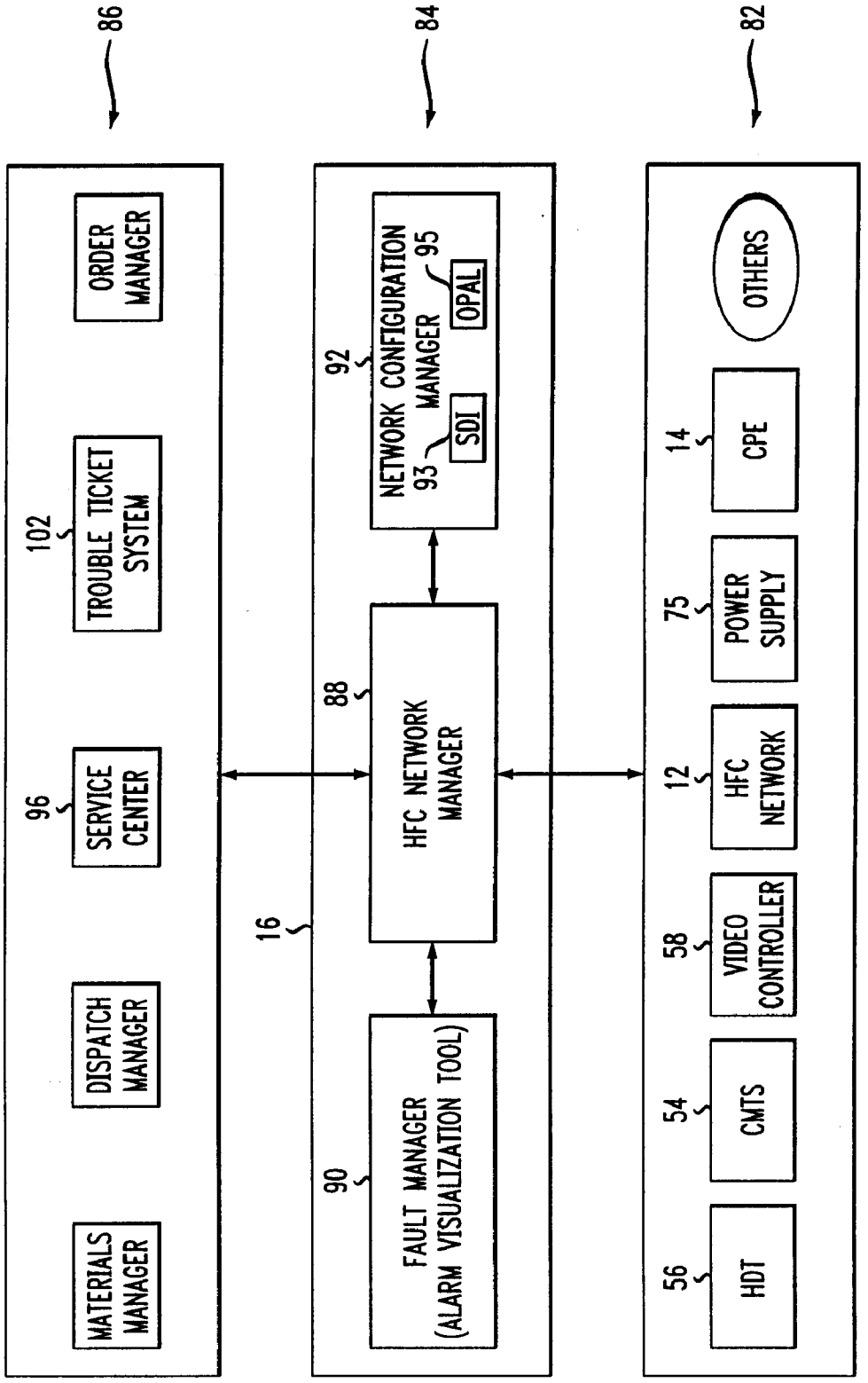

80
86
84
82
ORDER MANAGER
TROUBLE TICKET SYSTEM
102
SERVICE CENTER
96
DISPATCH MANAGER
MATERIALS MANAGER
16
92
NETWORK CONFIGURATION MANAGER
95
OPAL
SDI
93
88
HFC NETWORK MANAGER
90
FAULT MANAGER (ALARM VISUALIZATION TOOL)
OTHERS
14
CPE
75
POWER SUPPLY
12
HFC NETWORK
58
VIDEO CONTROLLER
54
CMTS
56
HDT

FIG. 5

110

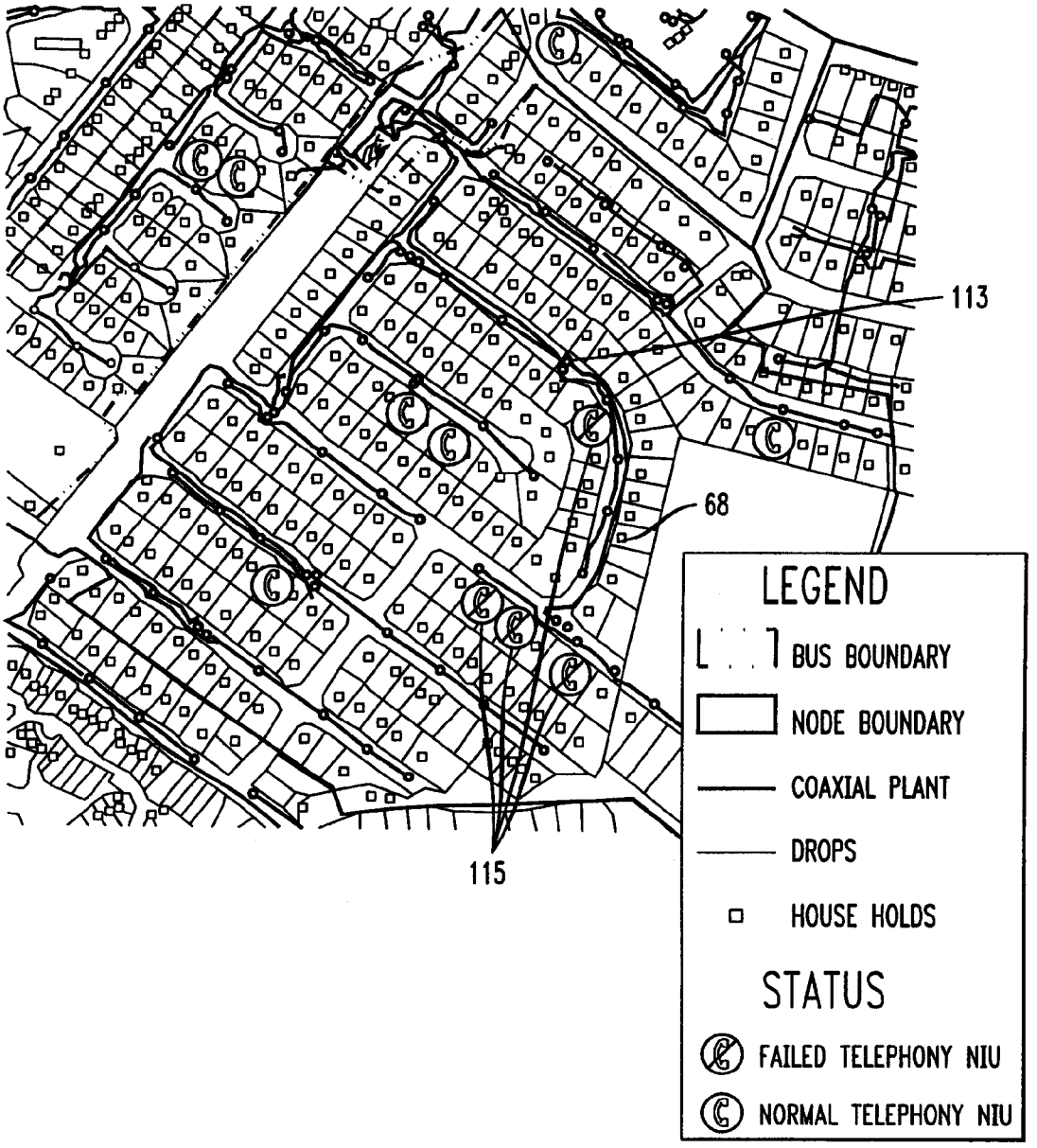

113
68
115
LEGEND
BUS BOUNDARY
NODE BOUNDARY
COAXIAL PLANT
DROPS
HOUSE HOLDS
STATUS
FAILED TELEPHONY NIU
NORMAL TELEPHONY NIU

FIG. 6

120

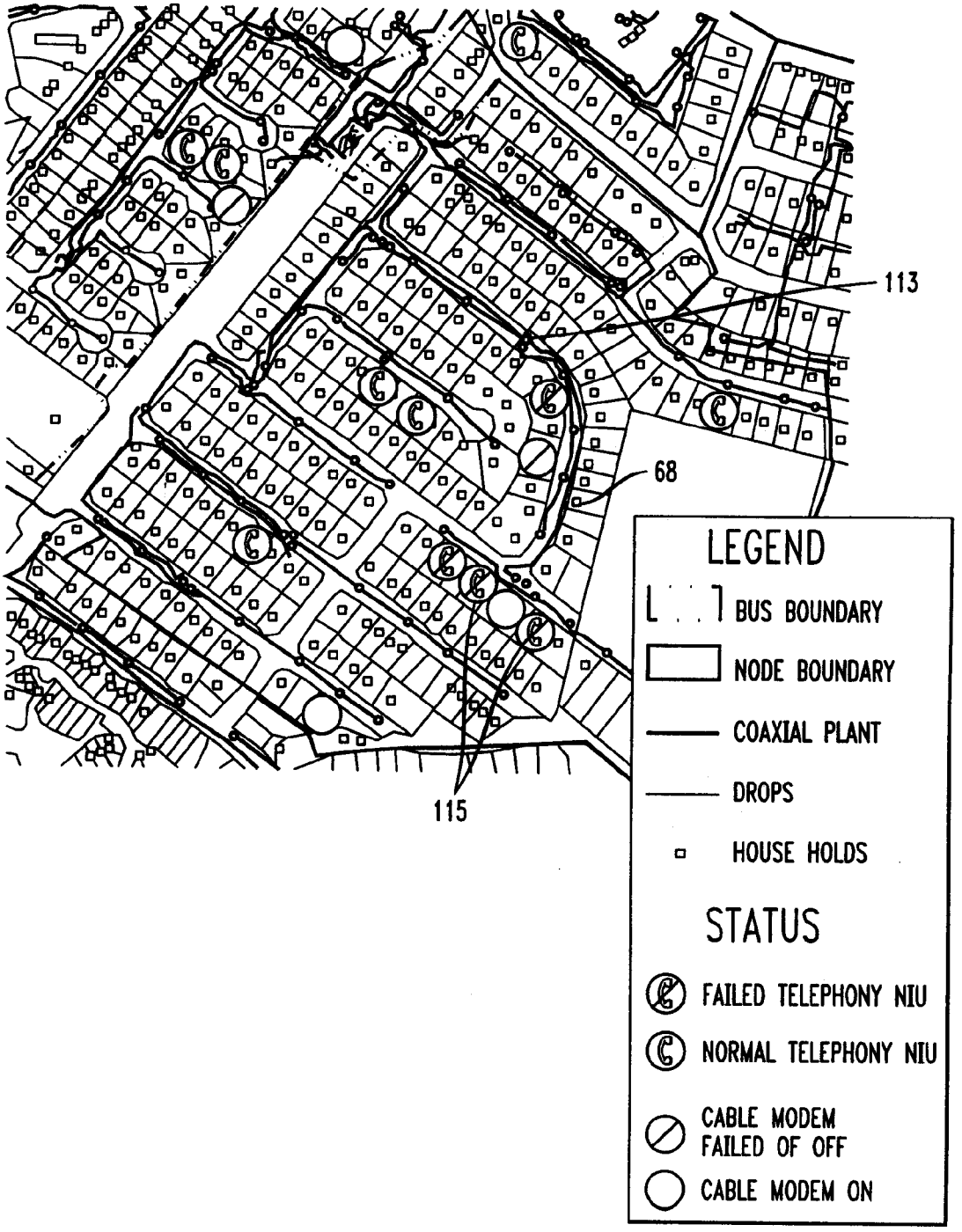
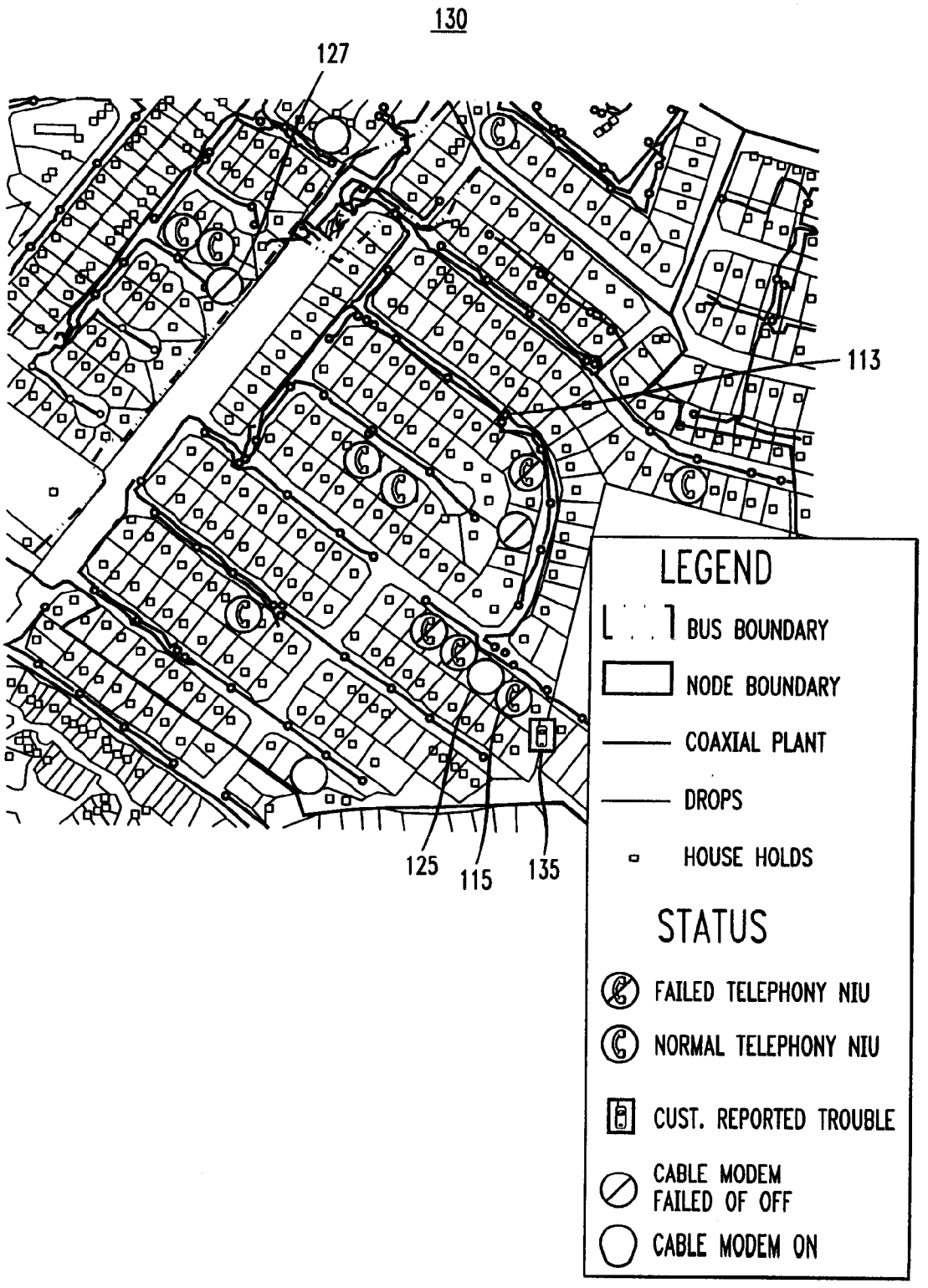

113
68
115
LEGEND
BUS BOUNDARY
NODE BOUNDARY
COAXIAL PLANT
DROPS
HOUSE HOLDS
STATUS
FAILED TELEPHONY NIU
NORMAL TELEPHONY NIU
CABLE MODEM FAILED OF OFF
CABLE MODEM ON

FIG. 7


130
127
113
125
115
135
LEGEND
BUS BOUNDARY
NODE BOUNDARY
COAXIAL PLANT
DROPS
HOUSE HOLDS
STATUS
FAILED TELEPHONY NIU
NORMAL TELEPHONY NIU
CUST. REPORTED TROUBLE
CABLE MODEM FAILED OF OFF
CABLE MODEM ON

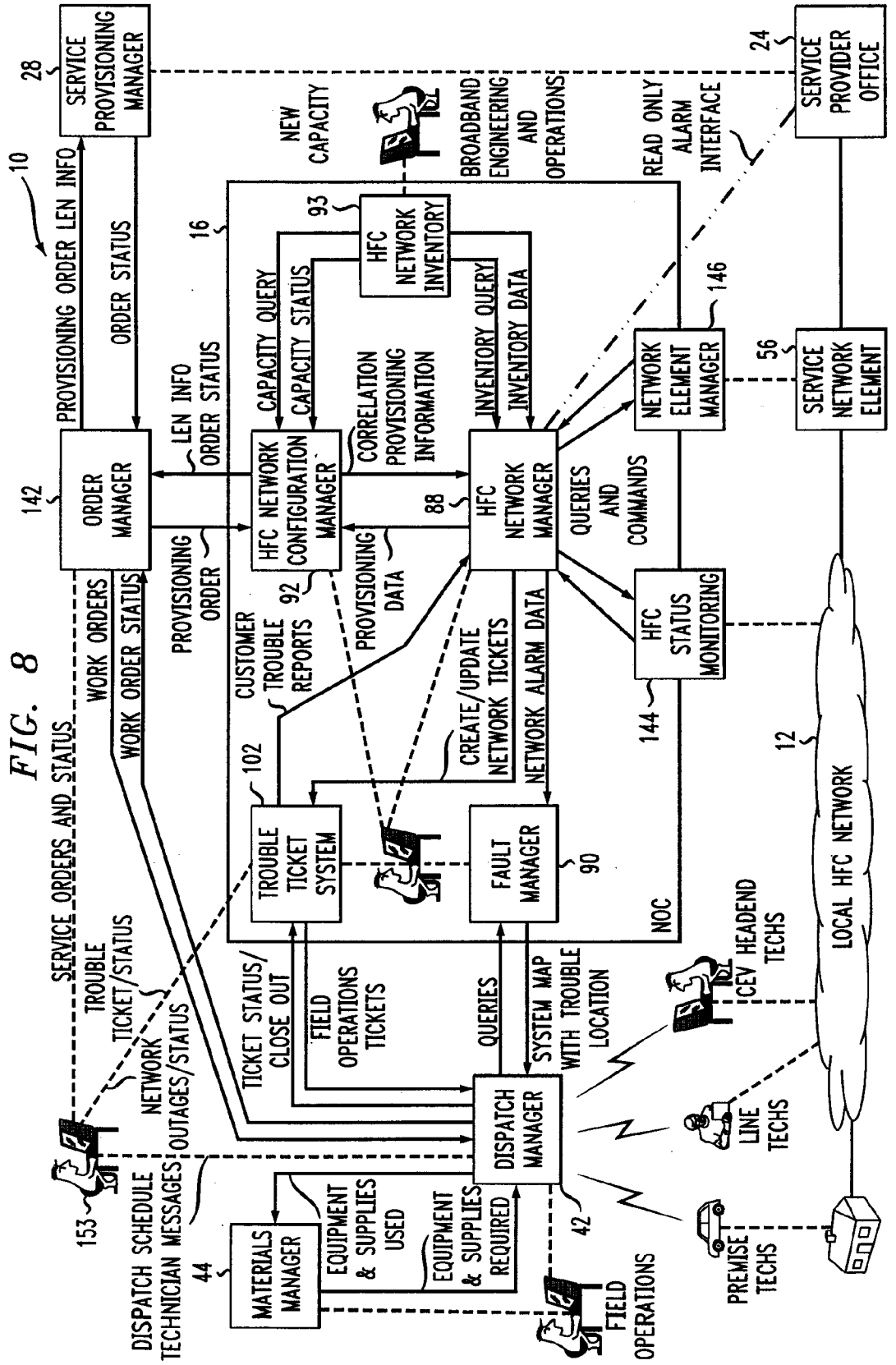

10
SERVICE PROVISIONING MANAGER
28
SERVICE PROVIDER OFFICE
24
PROVISIONING ORDER LEN INFO
ORDER STATUS
NEW CAPACITY
BROADBAND ENGINEERING AND OPERATIONS
READ ONLY ALARM INTERFACE
16
93
HFC NETWORK INVENTORY
CAPACITY QUERY
CAPACITY STATUS
INVENTORY QUERY
INVENTORY DATA
146
NETWORK ELEMENT MANAGER
56
SERVICE NETWORK ELEMENT
142
ORDER MANAGER
LEN INFO ORDER STATUS
HFC NETWORK CONFIGURATION MANAGER
CORRELATION PROVISIONING INFORMATION
88
HFC NETWORK MANAGER
QUERIES AND COMMANDS
PROVISIONING ORDER
PROVISIONING DATA
92
WORK ORDERS
WORK ORDER STATUS
CUSTOMER TROUBLE REPORTS
HFC STATUS MONITORING
144
SERVICE ORDERS AND STATUS
102
CREATE/UPDATE NETWORK TICKETS
NETWORK ALARM DATA
12
TROUBLE TICKET SYSTEM
FAULT MANAGER
90
NOC
LOCAL HFC NETWORK
TROUBLE TICKET/STATUS
NETWORK OUTAGES/STATUS
TICKET STATUS/ CLOSE OUT
FIELD OPERATIONS TICKETS
QUERIES
SYSTEM MAP WITH TROUBLE LOCATION
CEV HEADEND TECHS
153
DISPATCH SCHEDULE TECHNICIAN MESSAGES
DISPATCH MANAGER
LINE TECHS
MATERIALS MANAGER
44
EQUIPMENT & SUPPLIES USED
EQUIPMENT & SUPPLIES REQUIRED
42
PREMISE TECHS
FIELD OPERATIONS

FIG. 8

FIG. 9

260

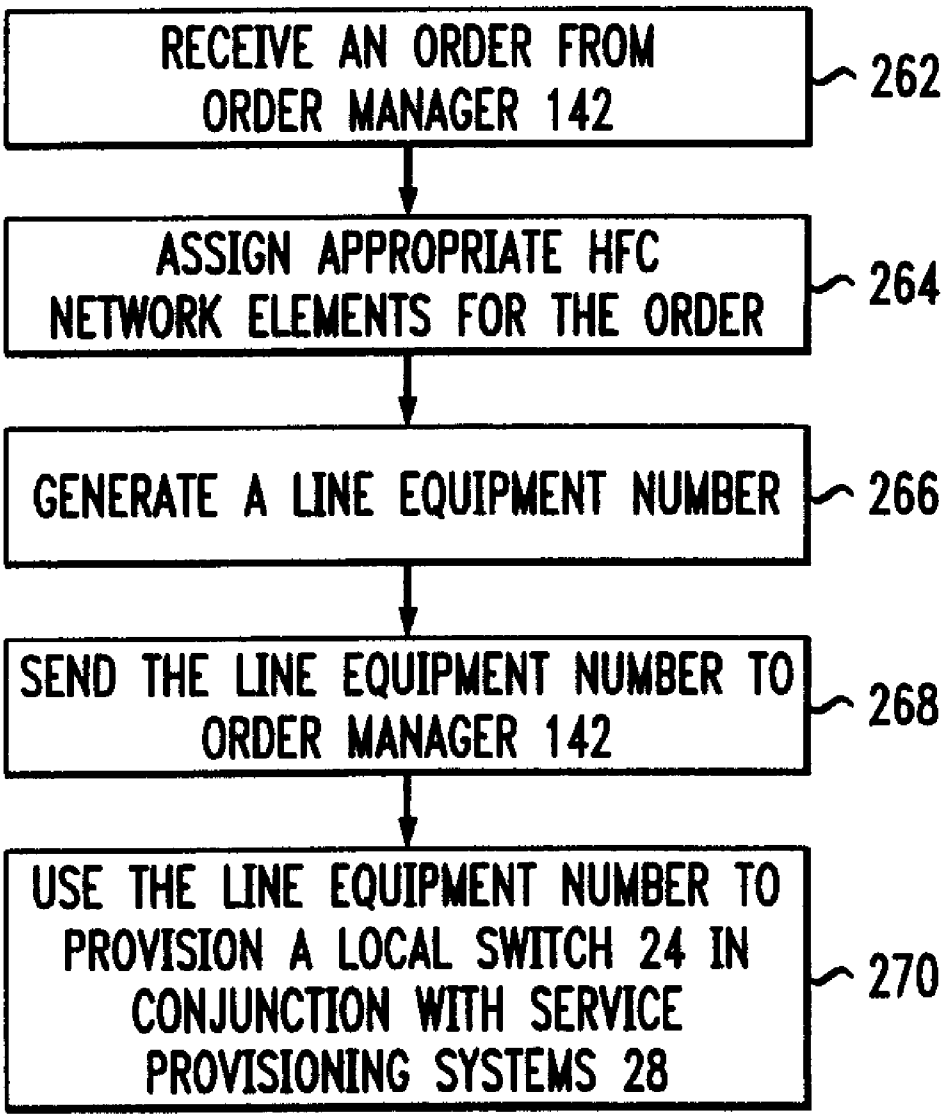

RECEIVE AN ORDER FROM ORDER MANAGER 142
262
ASSIGN APPROPRIATE HFC NETWORK ELEMENTS FOR THE ORDER
264
GENERATE A LINE EQUIPMENT NUMBER
266
SEND THE LINE EQUIPMENT NUMBER TO ORDER MANAGER 142
268
USE THE LINE EQUIPMENT NUMBER TO PROVISION A LOCAL SWITCH 24 IN CONJUNCTION WITH SERVICE PROVISIONING SYSTEMS 28
270

FIG. 10

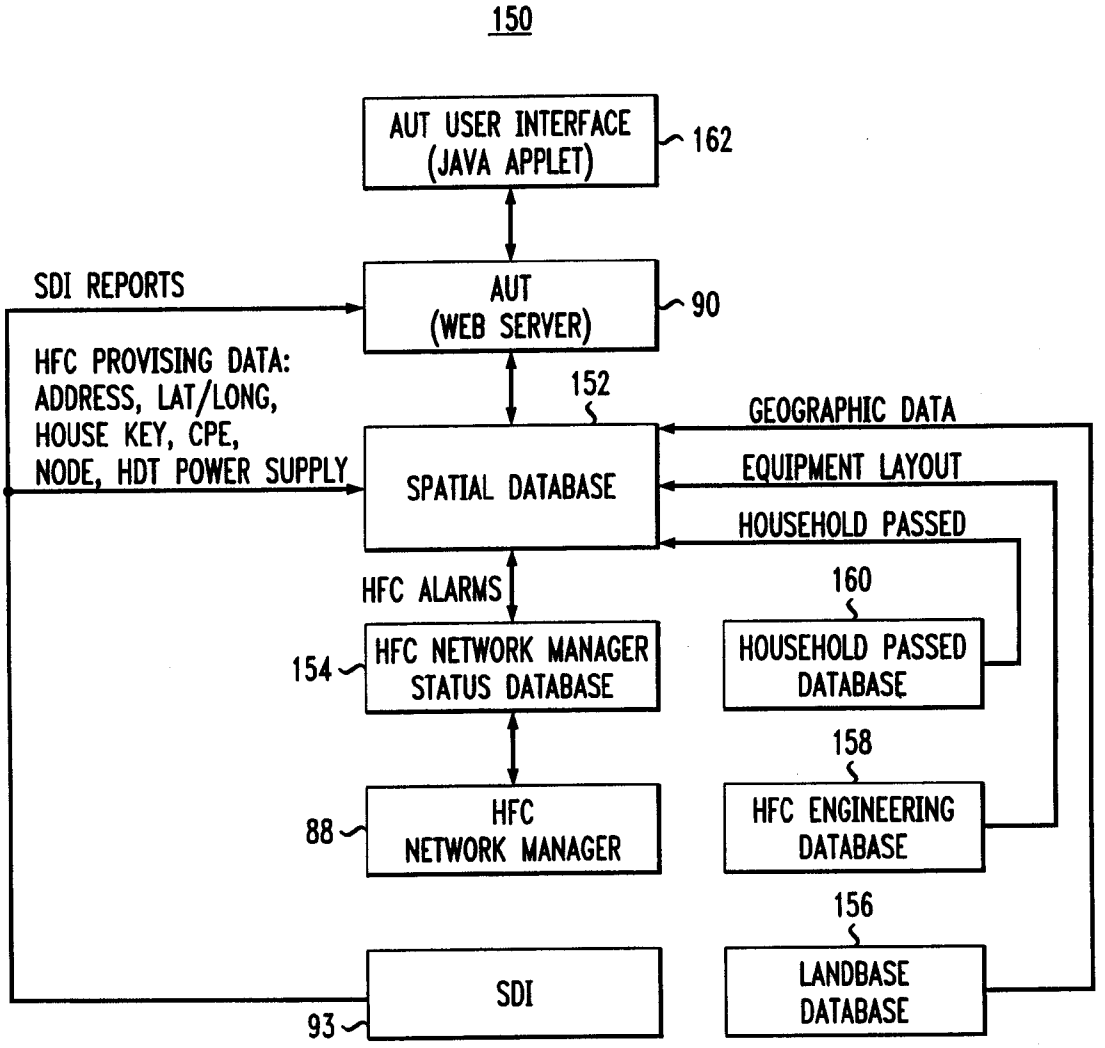

150
AUT USER INTERFACE (JAVA APPLET)
162
AUT (WEB SERVER)
90
SDI REPORTS
HFC PROVISING DATA: ADDRESS, LAT/LONG, HOUSE KEY, CPE, NODE, HDT POWER SUPPLY
152
SPATIAL DATABASE
GEOGRAPHIC DATA
EQUIPMENT LAYOUT
HOUSEHOLD PASSED
HFC ALARMS
160
HOUSEHOLD PASSED DATABASE
154
HFC NETWORK MANAGER STATUS DATABASE
158
HFC ENGINEERING DATABASE
88
HFC NETWORK MANAGER
156
LANDBASE DATABASE
SDI
93

FIG. 11

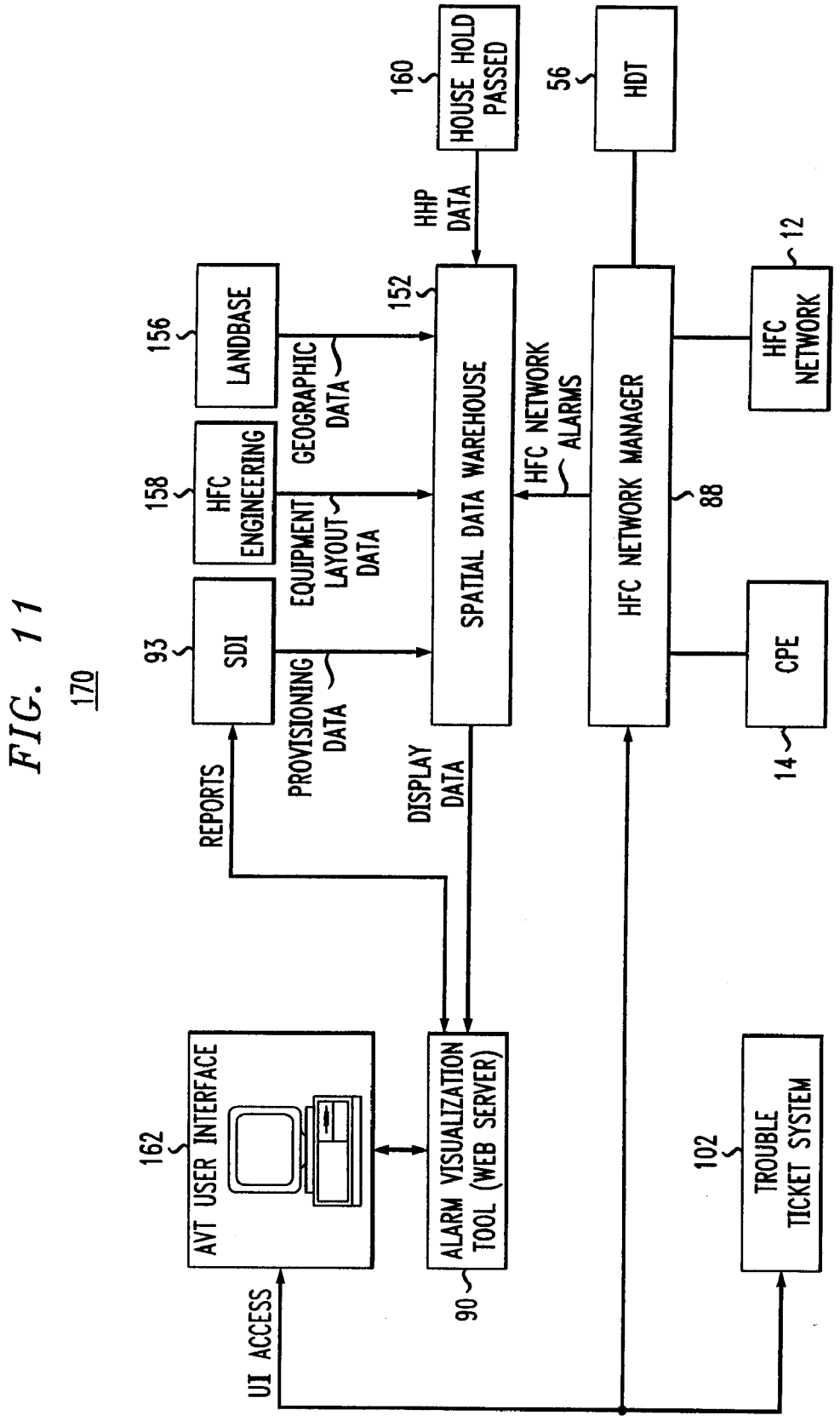

170
160
HOUSE HOLD PASSED
56
HDT
HHP DATA
152
SPATIAL DATA WAREHOUSE
156
LANDBASE
GEOGRAPHIC DATA
158
HFC ENGINEERING
EQUIPMENT LAYOUT DATA
93
SDI
PROVISIONING DATA
HFC NETWORK ALARMS
HFC NETWORK MANAGER
88
12
HFC NETWORK
CPE
14
REPORTS
DISPLAY DATA
162
AVT USER INTERFACE
ALARM VISUALIZATION TOOL (WEB SERVER)
90
102
TROUBLE TICKET SYSTEM
UI ACCESS

FIG. 12

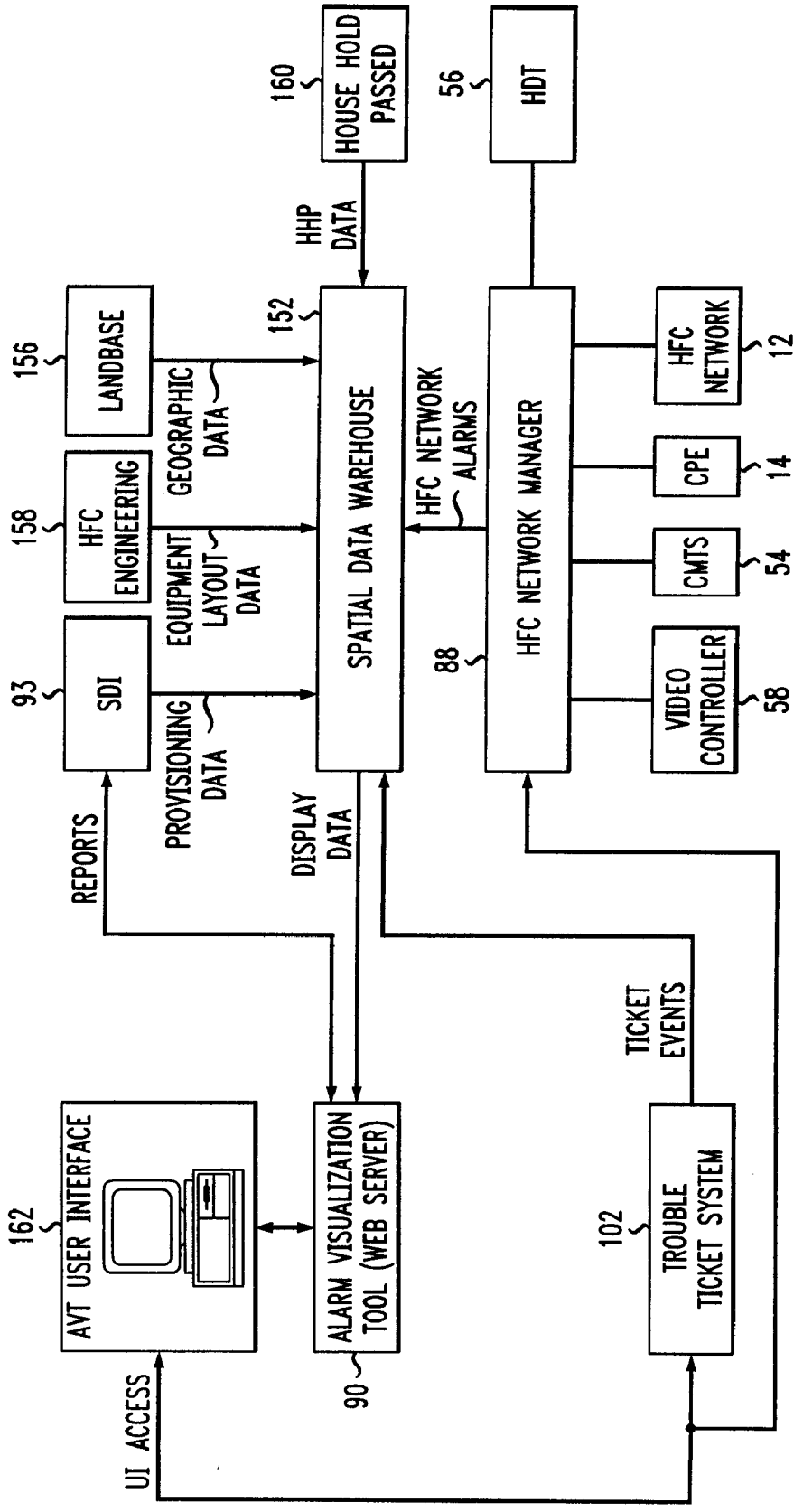

180
160
HOUSE HOLD PASSED
56
HDT
HHP DATA
152
SPATIAL DATA WAREHOUSE
156
LANDBASE
GEOGRAPHIC DATA
158
HFC ENGINEERING
EQUIPMENT LAYOUT DATA
93
SDI
PROVISIONING DATA
HFC NETWORK ALARMS
88
HFC NETWORK MANAGER
HFC NETWORK
12
CPE
14
CMTS
54
VIDEO CONTROLLER
58
REPORTS
DISPLAY DATA
TICKET EVENTS
162
AVT USER INTERFACE
ALARM VISUALIZATION TOOL (WEB SERVER)
90
102
TROUBLE TICKET SYSTEM
UI ACCESS

FIG. 13

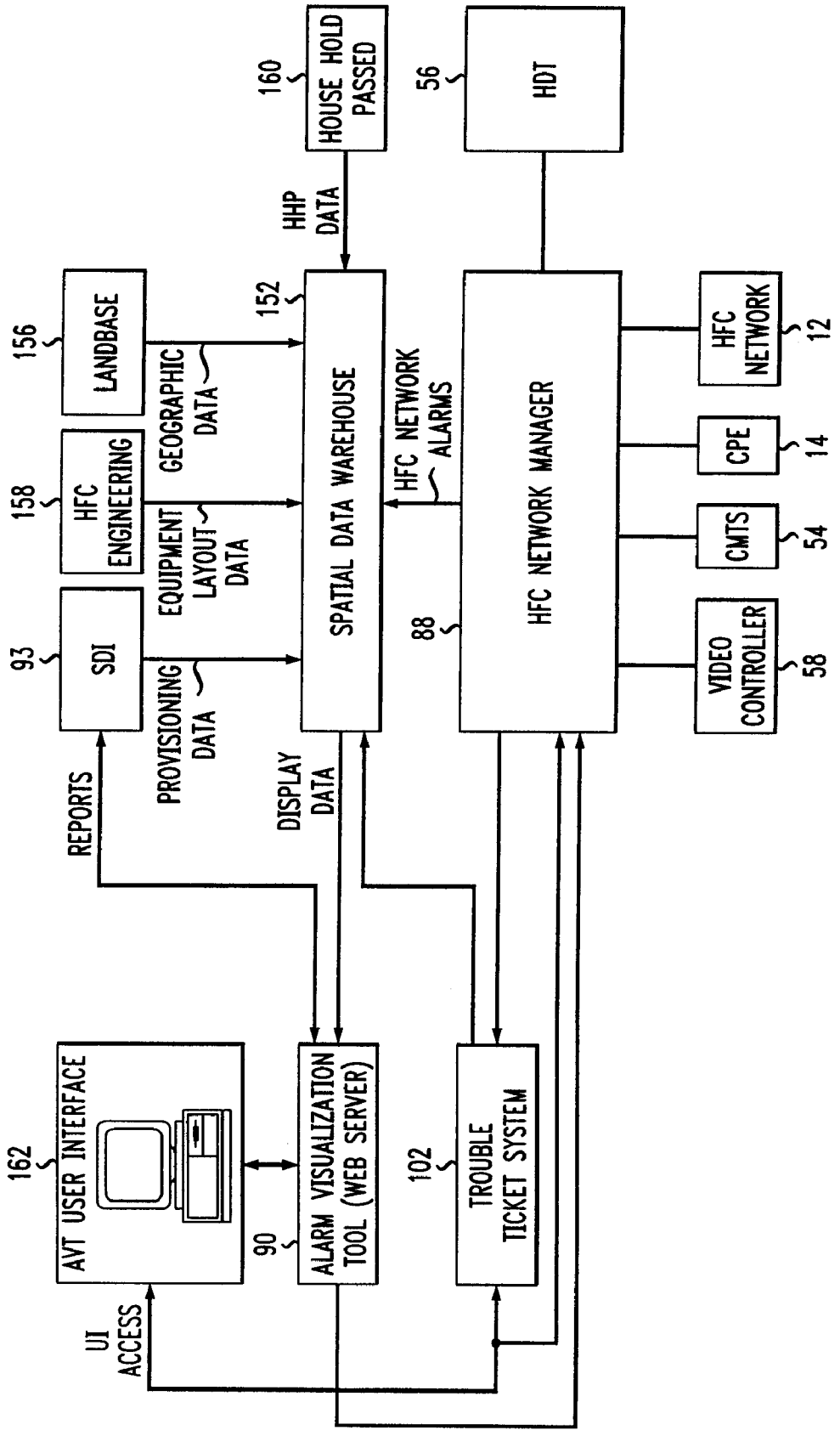
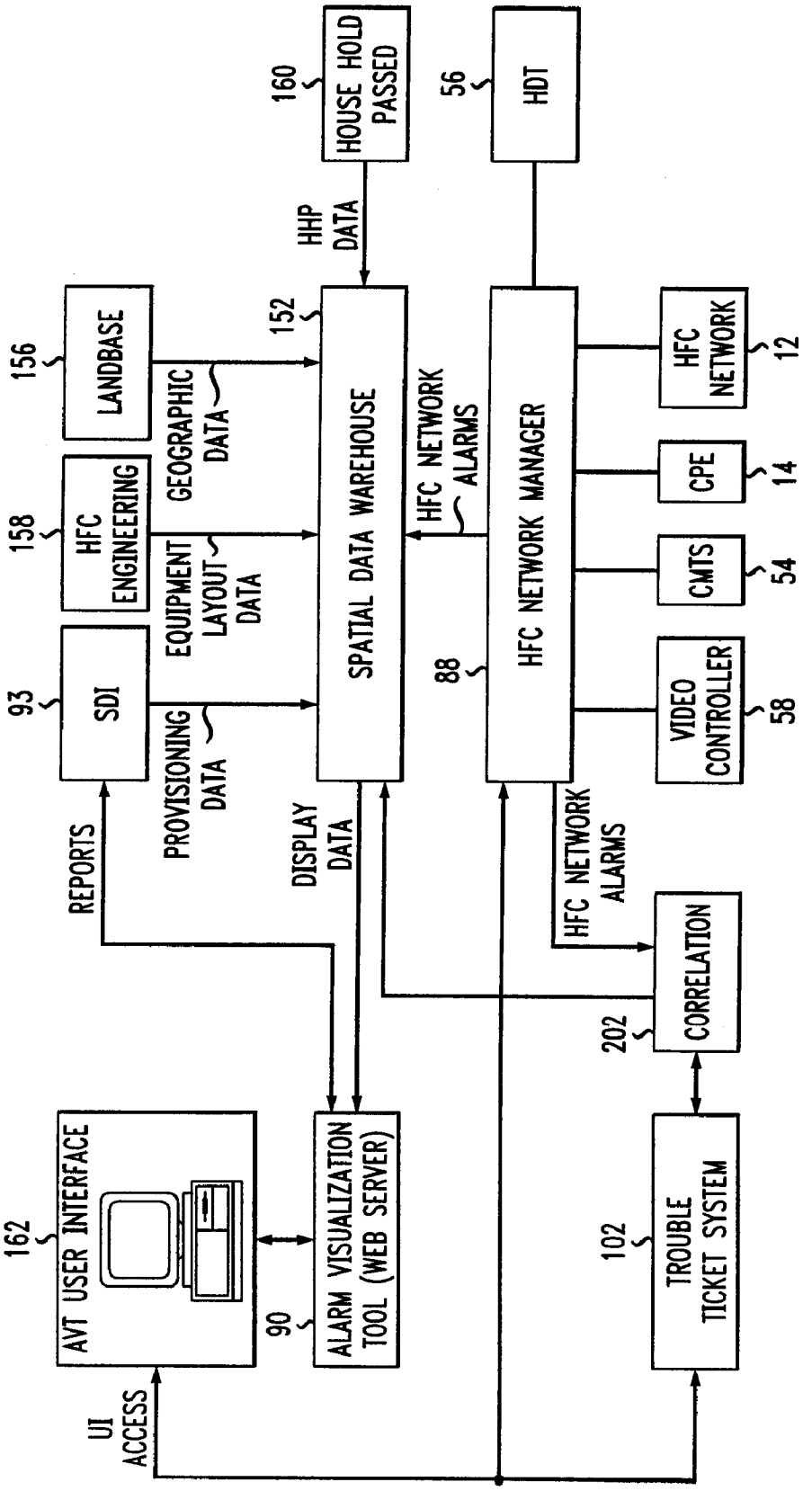

190
160
HOUSE HOLD PASSED
56
HDT
HHP DATA
152
SPATIAL DATA WAREHOUSE
156
LANDBASE
GEOGRAPHIC DATA
158
HFC ENGINEERING
EQUIPMENT LAYOUT DATA
93
SDI
PROVISIONING DATA
HFC NETWORK ALARMS
88
HFC NETWORK MANAGER
HFC NETWORK
12
CPE
14
CMTS
54
VIDEO CONTROLLER
58
REPORTS
DISPLAY DATA
162
AVT USER INTERFACE
90
ALARM VISUALIZATION TOOL (WEB SERVER)
102
TROUBLE TICKET SYSTEM
UI ACCESS

FIG. 14


200
160
HOUSE HOLD PASSED
56
HDT
HHP DATA
156
LANDBASE
152
SPATIAL DATA WAREHOUSE
HFC NETWORK MANAGER
HFC NETWORK
12
GEOGRAPHIC DATA
158
HFC ENGINEERING
EQUIPMENT LAYOUT DATA
HFC NETWORK ALARMS
CPE
14
CMTS
54
93
SDI
PROVISIONING DATA
88
VIDEO CONTROLLER
58
REPORTS
DISPLAY DATA
HFC NETWORK ALARMS
202
CORRELATION
162
AVT USER INTERFACE
90
ALARM VISUALIZATION TOOL (WEB SERVER)
102
TROUBLE TICKET SYSTEM
UI ACCESS

METHOD AND SYSTEM FOR GENERATING GEOGRAPHIC VISUAL DISPLAYS OF STATUS AND CONFIGURATION INCLUDING ASSIGNED CAPACITY OF HYBRID-FIBER COAX NETWORK ELEMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 09/850,910, filed May 8, 2001, now U.S. Pat. No. _____, which is hereby incorporated by reference in its entirety.

[0002] This application is related to: U.S. application Ser. No. 09/851,234, filed May 8, 2001, entitled "Network Management Method and System for Managing A Broadband Network Providing Multiple Services", now U.S. Pat. No. 6,952,729; U.S. application Ser. No. 09/851,235, filed May 8, 2001, entitled "Method and System for Provisioning Broadband Network Resources", now abandoned; and U.S. application Ser. No. 09/851,285, filed May 8, 2001, entitled "Method and System for Providing an Efficient Use of Broadband Network Resources", now U.S. Pat. No. 7,543,328.

BACKGROUND OF THE DISCLOSURE

[0003] 1. Field of the Disclosure

[0004] The present disclosure relates generally to broadband networks such as hybrid fiber coax (HFC) networks.

[0005] 2. Background Art

[0006] Broadband networks such as hybrid fiber coax (HFC) networks deliver video, telephony, data, and, in some cases, voice over Internet Protocol (VoIP) services to customers. Unlike traditional twisted pair local distribution networks, an HFC network must be managed to meet the capacity, availability, and reliability requirements of multiple services. Video, telephony, and data services share the same transport infrastructure to the customer's service location. Because this relationship exists, it is important that the set of HFC network management solutions meet the requirements of the HFC network and the requirements of the services transported by the HFC network to customers.

[0007] Previously, many of the infrastructure elements in an HFC network could not be actively monitored due to the limited availability of remote surveillance capabilities in the HFC network elements. Traditionally, local operations response and restoration methods relied heavily on the receipt and correlation of customer trouble reports to identify and sectionalize service-affecting conditions. HFC network element manufacturers did not actively pursue incorporating status-monitoring functionality because this increased the cost of the network elements for which there was no significant demand.

[0008] The introduction of high-speed data access and cable telephony services (along with traditional cable video services) into the HFC network created an immediate need for enhanced monitoring capabilities. This need is being addressed by the deployment of external transponders associated with HFC network elements such as power supplies and fiber nodes. Additional surveillance capabilities are provided via the deployment of enhanced service network elements (i.e., host digital terminals (HDT)/network interface units (NIU) for telephony, cable modem termination systems (CMTS)/cable modems for data access such as Internet access) and element management systems. While this equipment provides a higher-level status monitoring it provides only a logical network view at best. The ability of an HFC network management system to correlate alarms to physical plant outages requires a network inventory/configuration manager that contains accurate physical network topology data.

[0009] The ability to sectionalize HFC plant outages is important for many reasons. One of the most important reasons is that a typical local workforce is divided by skill sets and training into separate groups such as head end (HE) technicians responsible for the services equipment and distribution facilities located within the cable HE offices, line technicians responsible for the outside HFC distribution plant, and premises technicians responsible for customer-premises terminating equipment. The ability to determine where a problem resides allows the operator to dispatch the proper technician to the proper location to resolve the problem immediately. For example, this eliminates situations where a line technician is dispatched only to learn that there is a premises problem and vice versa.

[0010] The installation of increasing numbers of addressable intelligent end points in the HFC network (i.e., NIUs, cable modems) and transponders on HFC network elements along with network topology data provides the required information for an HFC network management system to monitor network and service performances levels. This can be achieved provided each of the HFC network elements and their location relative to the physical network are accurately represented in a database and are available to the operators responsible for HFC network surveillance Then, either automatically or via a network operations technician, notification can be sent to a properly qualified technician without the need for manual sectionalization and multiple dispatches. This capability will reduce response and repair times dramatically.

[0011] A critical component of HFC network customer service is the ability to rapidly identify and resolve HFC network issues. Accordingly, what is needed is a method and system for generating geographic visual displays which identify HFC network and supported service-affecting alarms and correlate these alarms to data such as customer proximity data, HFC plant and HFC network element proximity data, and connectivity proximity data for the resolution of alarms, problems, and customer service. Such geographic displays enable operators to determine what troubles are related to each other, in what segment of the HFC network the troubles are located, the customers impacted by the troubles, and the cause of the troubles.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** illustrates a simplified block diagram of a broadband network having a hybrid fiber coax (HFC) network in accordance with a preferred embodiment of the present disclosure;

[0013] FIG. **2** illustrates a more detailed view of the broadband network shown in FIG. **1**;

[0014] FIGS. **3** and **4** illustrate the Telecommunications Managed Networks (TMN) model of the HFC network management system in accordance with a preferred embodiment of the present disclosure;

[0015] FIGS. **5**, **6**, and **7** illustrate examples of visual correlation displays generated by the alarm visualization tool of the HFC network management system;

[0016] FIG. **8** illustrates a highly detailed view of the HFC network management system and the broadband network;

[0017] FIG. **9** illustrates a flow chart describing operation of the automation of HFC network provisioning in accordance with a preferred embodiment of the present disclosure;

[0018] FIG. **10** illustrates a block diagram describing the architecture of the alarm visualization tool (AVT) of the HFC network management system and associated AVT data flow; and

[0019] FIGS. **11**, **12**, **13**, and **14** illustrate respective block diagrams of the AVT within first, second, third, and fourth HFC network management configurations.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0020] The present disclosure discloses an embodiment of a system which includes a hybrid fiber coax (HFC) network having network elements operable for communicating telephony, data, and video signals with customer-premises equipment (CPE) of subscribers. The system further includes an HFC network manager operable for monitoring status and the configuration including the assigned capacity of the network elements and for generating alarm data indicative of improper status or configuration of the network elements. The system further includes a service, design, and inventory (SDI) database operable with the HFC network manager for storing data indicative of the status and the configuration of the network elements and for storing data indicative of physical and logical connections between the network elements and the CPE. The system further includes a fault manager having an alarm visualization tool operable with the HFC network manager and the database for generating visual displays of the status and configuration including the assigned capacity of the network elements overlaid with the alarm data and overlaid with the physical and logical connections between the network elements and the CPE based on the stored data.

[0021] The present disclosure discloses an embodiment of another system in which the system includes a HFC network having network elements operable for communicating telephony, data, and video signals with CPE. This system further includes an HFC network manager operable for monitoring status of the network elements and the CPE of subscribers, for monitoring the configuration including the assigned capacity of the network elements and the CPE, and for generating alarm data indicative of improper status or configuration of the network elements and the CPE. This system further includes a service, design, and inventory (SDI) database operable with the HFC network manager for storing data indicative of the status and the configuration of the network elements and the CPE and for storing data indicative of physical and logical connections between the network elements and the CPE. This system further includes a fault manager having an alarm visualization tool operable with the HFC network manager and the database for generating visual displays of the status and configuration including the assigned capacity of the network elements and the CPE overlaid with the alarm data and overlaid with the physical and logical connections between the network elements and the CPE based on the stored data.

[0022] The present disclosure discloses an embodiment of a method for a HFC network provided with network elements operable for communicating telephony, data, and video signals with CPE of subscribers. The method includes monitoring status of the network elements and monitoring the configuration including the assigned capacity of the network elements. The method further includes generating alarm data indicative of improper status or configuration of the network elements. The method further includes storing data indicative of the status and the configuration of the network elements. The method further includes storing data indicative of physical and logical connections between the network elements and the customer-premises equipment. The method further includes generating visual displays of the status and configuration including the assigned capacity of the network elements overlaid with the alarm data and overlaid with the physical and logical connections between the network elements and the customer-premises equipment based on the stored data.

[0023] Referring now to FIG. **1**, a broadband network **10** in accordance with a preferred embodiment of the present disclosure is shown. Broadband network **10** includes a hybrid fiber coax (HFC) network **12** for distributing telephony, data, and video (and voice over Internet Protocol (VoIP)) services to a customer **14** connected to the HFC network. An HFC network management system **16** is operable with HFC network **12** for managing the HFC network. In general, HFC network management system **16** focuses on the provisioning, maintenance, and assurance of telephony, data, video and VoIP services over HFC network **12** for a customer **14**. HFC network management system **16** provides automated system capabilities in the areas of HFC services, network element provisioning, and fault management.

[0024] HFC network **12** is operable for receiving and transmitting telephony, data, and video signals from/to a telephony service network **18**, a data service network **20**, and a video service network **22**. HFC network **12** distributes telephony, data, and video signals from respective networks **18**, **20**, and **22** to a customer **14** connected to the HFC network. Telephony service network **18** includes a local switch **24** for connecting the public switched telephone network (PSTN) **26** to HFC network **12** and a local switch operations center **28** for controlling the local switch.

[0025] Similarly, data service network **20** includes a data router **30** for connecting an Internet Protocol (IP) data network **32** to HFC network **12** and a Internet Service Provider (ISP) operations center **34** for controlling the router. Video service network **22** includes a video controller **36** for connecting a video source **38** to HFC network **12** and a video operations center **40** for controlling the video controller.

[0026] Customer **14** includes customer-premises equipment (CPE) elements for connecting with HFC network **12** to receive/transmit the telephony, data, and video signals. A local dispatch operations center **42** assists in provisioning the desired network elements to customer **14**. Local dispatch operations center **42** communicates with a local inventory operations database **44** to select a desired (CPE) element **46** stored in a local inventory **48**. Such CPE elements **46** include a set-top box (STB) for video service, a network interface unit (NIU) for telephony service, and a cable modem for data service. A qualified installer **50** receives instructions from local dispatch operations center **42** for installing a desired CPE element **46** stored in local inventory on the premises of customer **14**.

[0027] Referring now to FIG. **2**, a more detailed view of broadband network **10** is shown. Broadband network **10** includes a cable network head-end/hub office **52**. Data router **30**, local switch **24**, and video controller **36** are operable with hub office **52** to transmit/receive data, telephony, and video signals to/from customer **14** via HFC network **12**. Hub office **52** includes a cable modem termination system (CMTS) **54**

for communicating data signals such as IP data to/from data router **30**; a host digital terminal (HDT) **56** for communicating telephony signals to/from local switch **24**; and video equipment **58** for communicating video signals to/from video controller **36**.

[0028] The head end of HFC network **12** is located within hub office **52** and connects with CMTS **54**, HDT **56**, and video equipment **58** for distributing the data, telephony, and video signals to/from customer **14**. Specifically, HFC network **12** includes a combiner/splitter network **60** connected to CMTS **54**, HDT **56**, and video equipment **58**. For communicating signals to customer **14**, combiner/splitter network **60** combines the data, telephony, and video signals into a combined signal and provides the combined signal to optical equipment **62**. Optical equipment **62** (such as a primary or secondary hub ring) converts the combined signal into an optical signal and distributes the combined optical signal to a fiber node **64** via optical fibers **66**. Fiber node **64** is generally located in the neighborhood of customer **14**. A typical fiber node serves up to 1,200 customers and is powered by a power supply **75**. Power supply **75** generates status information and has a transponder for communicating the status information to HFC network management system **16**. Fiber node **64** converts the combined optical signal into a combined electrical signal for distribution on coaxial cable **68** located in the neighborhood of customer **14**. An amplifier **70** amplifies the combined electrical signal and then provides the combined electrical signal to a fiber node bus **73** and a port **72** associated with customer **14**.

[0029] Customer **14** includes customer-premises equipment such as a cable modem **74**, a network interface unit (NIU) **76**, and a set-top box (STB) **78**. Cable modem **74** extracts the data signal from the combined electrical signal; NIU **76** extracts the telephony signal from the combined electrical signal; and STB **78** extracts the video signal from the combined electrical signal. In order to communicate signals from customer **14** to hub office **52** for receipt by data router **30**, local switch **24**, and video controller **36**, the signal flow process is reversed and combiner/splitter network **60** in hub office **52** splits the signal from the customer to the appropriate service network (data, telephony, or video).

[0030] Referring now to FIG. **3**, a model **80** implementing HFC network management system **16** is shown. In general, the system capabilities within HFC network management system **16** are designed to adhere to the Telecommunications Managed Networks (TMN) model of the International Telecommunications Union. In accordance with the TMN model, model **80** includes an element management layer **82**, a network management layer **84**, and a service management layer **86**. The service and provisioning systems provided by HFC network management system **16** spans all three management layers **82**, **84**, and **86**.

[0031] Element management layer **82** is the physical equipment layer. Element management layer **82** models individual pieces of equipment such as HDTs **56**, CMTSs **54**, video equipment **58**, cable modems **74**, NIUs **76**, and STBs **78** along with facility links in HFC network **12**. Element management layer **82** further models the data and processes necessary to make the equipment and facility links provide desired functionality. Element management layer **82** passes information to network management layer **84** about equipment problems, and instructions are received by the network management layer to activate, modify, or deactivate equipment features.

[0032] Network management layer **84** includes network management system **16**. Network management system **16** generally includes a network manager **88**, a fault manager **90**, a network configuration manager **92**, and a network operations center (NOC) **94** as will be described in greater detail below. Network management layer **84** deals with the interfaces and connections between the pieces of equipment. As such, network management layer **84** breaks down higher-level service requests into actions for particular systems required to implement these requests. Without a connectivity model, individual equipment systems are merely islands that must be bridged by human intervention.

[0033] Service management layer **86** associates customers **14** with services provided by HFC network **12**. Business service centers such as telephony service center **96**, data service center **98**, and video service center **100** are the primary part of service management layer **86** because they allow customers to request service. The provisioning activity originates from service management layer **86**. Service management layer **86** further includes a trouble ticket system **102** for issuing trouble tickets to a local operations center **104**.

[0034] In general, model **80** illustrates the systems and interfaces that support the functions of HFC network management system **16** with respect to HFC network **12** and the services that are provided by the HFC network. These functions, together with processes and systems, support business requirements such as HFC automated provisioning, automated trouble ticket creation and handling, and automated data analysis and reporting.

[0035] The functions of HFC management system **16** generally include HFC network-specific functions, services-specific network management functions, and HFC network- and services-specific functions. The HFC network-specific functions are status monitoring (surveillance), HFC network management, fault management (alarm correlation and trouble isolation), and performance management. The services-specific network management functions are network capacity management, service assurance (trouble ticketing and administration), network element management (elements are service-specific, e.g., HDTs support telephony service, CMTSs support data services, etc.), performance management, and system management (routers). The HFC network- and services-specific functions are configuration management and provisioning.

[0036] The processes and systems related to the functions of HFC management system **16** include sources of network topology data, network inventory and configuration management, network and services provisioning, network surveillance, network alarm correlation, network fault management, capacity management, service assurance, HFC telephony, data, and video element management systems, and system management.

[0037] By integrating the functions, processes, and systems described above HFC network management system **16** can support various integrated applications. These integrated applications include automated HFC provisioning for telephony services, auto trouble ticket creation, visual outage correlation, and customer service representation.

[0038] Referring now to FIG. **4**, a block-level illustration of HFC network management system **16** implementation of the TMN model is shown. As described with reference to FIG. **3**, element management layer **82** includes network elements **54**, **56**, and **58**, HFC network **12**, power supply **75**, customer-premises elements **14**, and other equipment. Element man-

agement layer **82** provides status information regarding these elements to HFC network manager **88** of HFC network management system **16** located in network management layer **84**. HFC network manager **88** provides instructions to element management layer **82** on how to configure the elements located in the element management layer. HFC network manager **88** also provides information to service management layer **86** regarding the configuration of the elements within the element management layer and whether there are any problems with the configuration.

[0039] In general, HFC network management system **16** provides mechanization and automation of operation tasks for HFC network **12**. In order to support these operation tasks, network management layer **84** of HFC network management system **16** includes HFC network manager **88**, a fault manager **90**, and a network configuration manager **92**. Fault manager **90** includes a geographical information system tool referred to herein as an alarm visualization tool (AVT). AVT **90** supports visual correlation of network elements and customer impact. Network configuration manager **92** includes a service, design, and inventory (SDI) system **93** having a database representing HFC network **12**. SDI database **93** stores data representing the assigned capacity of HFC network **12**. Network configuration manager **92** further includes an online provisioning application link (OPAL) **95**. OPAL **95** accommodates automated provisioning of services to customers. The association of HFC system- and service-specific network elements and associated facilities provides surveillance and fault management tools that aid network operations center **94** and local operations center **104** to respond to service-affecting network events.

[0040] A brief overview of the main components in model **80** will now be described. Trouble ticket system **102** of service management layer **86** is used to support customer trouble management and the fault management process of HFC network management system **16**. Trouble ticket system **102** supports all services (telephony, data, and video) and supports automated data collection for analysis and reporting systems. Interfaces to HFC network manager **88** and SDI system **93** are implemented to support network-generated tickets and field maintenance trouble referrals.

[0041] AVT **90** demonstrates and verifies the applicability of graphical visualization of HFC network **12** and service alarms. AVT **90** includes capabilities for assisting telephony, video, and data maintenance operations in the trouble sectionalization, isolation, and resolution process. AVT **90** provides geographical displays with varying zoom levels (from country to street and household level) overlaid with node boundary, distribution plant layout, and equipment at single dwelling unit (SDU) and multiple dwelling unit (MDU) premises. The views of AVT **90** also represent switch and head end locations, associated hubs, secondary hubs, and connectivity between them. Alarm and status information are shown via color codes and icon size of the equipment representations. AVT **90** displays ticket indicators as representations (icons) separate from alarms. Through these geographical views an operator will be able to visually correlate event information. AVT **90** also assists operators in initiating trouble resolution processes via the ability to launch trouble tickets from the displays. AVT **90** also allows context sensitive access to diagnostics.

[0042] HFC network manager **88** supports the alarm surveillance and fault management process. HFC network manager **88** includes a rules-based object-oriented system to support auto ticket creation through trouble ticket system **102** and a geographic information system for visual correlation and alarm correlation with support from SDI system **93**.

[0043] SDI system **93** is a network configuration management application that supports HFC network provisioning, fault management, and capacity management processes. The database of SDI system **93** also serves as the database of record for supporting the alarm correlation of the fault management process. OPAL **95** provides auto provisioning functionality with the assistance of SDI system **93**.

HFC Network-Specific Functions

[0044] The network-specific functions are functions that are common to HFC network **12** regardless of the services (telephony, data, video) that are offered by HFC network.

[0045] 1. Status Monitoring

[0046] Status monitoring for the HFC plant includes telemetry information and is deployed in all power supplies and fiber nodes. This technology contributes to network availability by enabling preemptive maintenance activities to head off network outages. Status monitoring alerts are useful in detecting problems with standby inverter batteries. This alone enables proactive maintenance to ensure the ability to ride through short-duration electric utility outages. Alerts from cable plant power supplies also determine when standby generators should be deployed to maintain powering through long-duration commercial power outages. Upstream spectrum management systems are deployed to accept autonomously generated messages that indicate a degraded condition in the upstream bands. Fundamentally, these systems are spectrum analyzers with the capability of masking normal spectrum behaviors from abnormal conditions and reporting such abnormalities.

[0047] 2. Network Management

[0048] HFC network manager **88** supports fault management functions for HFC network **12**. Included in the supported fault management functions are surveillance of the HFC outside plant, message filtering, basic alarm management (e.g., notify, clear, retire alarms), and test access support. HFC network manager **88** also supports visual alarm correlation, management of some provisioning command execution, and exporting status and traffic information to network operations center **94**.

[0049] HFC network manager **88** aggregates device fault information and includes a software system that allows development of message-processing rules and behaviors. HFC network manager **88** includes standard modules for communicating with any network protocol. The software resides on a server in each local market. This ensures scalability, reliability, local visibility, fault location, and a distributed computing environment. The numerous connectivity capabilities ensure that HFC network manager **88** can communicate with AVT **90**, SDI system **93**, and OPAL **95**.

[0050] HFC network manager **88** is the primary tool available to technicians of network operations center **94**. Because HFC network manager **88** interfaces to the various-vendor provided element management systems, the HFC network manager provides a uniform view for network operations center **94** into those systems. This insulates the technicians from each piece of equipment that has its own particular management system and protocol. Additionally, the current fault rule sets perform one universal function of displaying faults as messages are received and clearing the fault when a corresponding clear is received. This contrasts with many

vendor element management systems which provide a continuously streaming arrays of messages where faults and clears are shown on the same screen sorted by time only.

[0051] Because HFC network manager **88** is a rule-based system, the HFC network manager can implement advanced criteria designed by network and equipment subject-matter experts into tangible behaviors described below. Such behaviors are a powerful tool for managing the projected numbers of faults.

[0052] 3. Fault Management

[0053] Prior to HFC network management system **16**, manual correlation of information available from network elements was used to isolate problems. Incoming alarms were read from tabular listings on multiple workstations. Additional information was then obtained about location and serving area from databases, maps, and spreadsheets. Trouble tickets were reviewed to see if related customer problems existed. This method demonstrated the effectiveness of correlation, but is very time consuming and may result in details being overlooked due to the manual nature of the process.

[0054] The present disclosure provides enhanced correlation methods for fault management can be obtained through a strategy that combines automated, visual, and cross-product correlation of customer-reported problems and status information from intelligent network elements. The present disclosure presents this information in an automated user-friendly fashion, network managers can quickly isolate problems in the network as to their root cause and location.

[0055] HFC network manager **88** is the data collection and processing engine for telephony, data, and video equipment. Alerts from element managers and customer-reported problem data from trouble ticketing system **102** are managed by HFC network manager **88**. HFC network manager **88** processes these alerts against predefined rule sets to perform advanced correlation. HFC network manager **88** dips into the database of SDI system **93** to look up the logical relationships and service address information that the calculations require. HFC network manager **88** stores the results from the correlation processing in a database.

[0056] AVT **90** is used in parallel to automated event correlation. AVT **90** includes a spatial database that relates alarm information from HFC network manager **88** with network configuration data from the database of SDI system **93**, geocoded homes passed information, and landbase and spatial data. AVT **90** is a web-based graphics tool that allows network operations center **94** to view real-time status of faults in broadband network **10**. This maximizes the efficiency and effectiveness of network operations center **94** in identifying telephony alarms and correlation of these alarms to customer proximity, plant and equipment proximity, and connectivity proximity for the resolution of alarms, problems, and customer service.

[0057] The following sections describe how automated correlation along with visual and cross-product correlation is performed in accordance with a preferred embodiment of the present disclosure. In addition, the description of reports that are generated by SDI system **93** in support of the fault management is provided.

[0058] a. Automated Correlation

[0059] Systems that can perform automated correlation of managed elements are needed to establish associations between problems with customer's service and the equipment that delivers those services. In order to perform automated correlation, logical connectivity relationships need to be established between the elements of broadband network **10** and the common equipment and transmission paths. A database (the database of SDI system **93**) representing the local network connectivity (HFC infrastructure) and the elements connected to the network will enable the delivery of services (telephony, data, and video) to a customer location. This database is needed as a source of reference for HFC network management system **16**. In order to support fault management capability through automated correlation, the database of SDI system **93** must be an accurate database. The database of SDI system **93** models and inventories head end equipment, fiber node, and CPE. Connectivity and serving area information for this equipment is established as part of the provisioning process for advanced services.

[0060] b. Visual Correlation

[0061] Visual correlation enables network operations center **94** to relate the location of faulted CPE with HFC network **12** feeding them. AVT **90** displays street maps of the regions that have been overlaid with HFC cable plant diagrams. These maps also show the serving area boundaries for each fiber node. In addition to this static information, color-coded dynamic symbols representing type of service, status of intelligent network elements, and the customer-reported problems are also displayed. Geo-coding of network elements and customer service addresses enables the symbols to be accurately located on the maps relative to the streets and physical plant. This method quickly presents a visual indication of services that are experiencing problems and the location of customers impacted.

[0062] c. Cross-Product Correlation

[0063] Correlation is significantly more powerful when multiple services are provided. By determining if one or more products in the same section of the network are experiencing problems or are operating normally, common equipment and transmission paths can be identified and eliminated as the trouble source.

[0064] FIG. **5** illustrates an example of a visual correlation display **110** of some failed telephony NIUs **115** generated by AVT **90**. Display **110** provides a great deal of information about the location of a telephony problem. In addition to the failed telephony NIUs **115**, display **110** shows the importance of knowing what is in the normal state. In display **110** it is still uncertain if the problem is in cable plant **68** or head end **52**. It appears that a single amplifier **113** feeds all the failed telephony NIUs **115**.

[0065] Automated correlation information can further isolate the problem by indicating if the same modem equipment in head end **52** serves all the failed cable modems **127**. It could also indicate if any working cable modems **125** are served by the same modem equipment in head end **52**. If they are not, or there are working devices off that same modem equipment in head end **52**, then it is likely that the problem is in cable plant **68**. If they are served by the same modem equipment in head end **52**, then trouble location is not certain. Additional information from other products could contribute in further isolating the problem.

[0066] FIG. **6** illustrates a second visual correlation display **120** generated by AVT **90**. Display **120** includes Internet cable modem status information. Correlation can now be made against cable modems **125** and **127**. In the area of the failed telephony NIUs **115** there is one operating cable modem **125**. Even though other modems in the node are turned off this one piece of information indicates that cable plant **68** serving this area may be properly functioning. Look-

ing for trouble at head end **52** may make more sense than sending a technician to look for line problems, particularly if all the failed telephony devices **115** are off the same cable modem equipment in head end **52**.

[0067] In addition to the alarm data from the intelligent network elements, trouble ticketing system **102** provides the address and trouble type information from customer-reported problems. This is also displayed on the mapping system. The report clusters from this source can be useful in identifying soft failures, degradation, or content problems that are not accompanied by active elements but impact service.

[0068] FIG. **7** illustrates a third visual correlation display **130** generated by AVT **90** which includes a new symbol **135** that indicates customer-reported troubles. Visual or automated correlation desirably includes all elements in HFC network **12** which could possibly become single points of failure for different services or service areas. This includes network elements which are physically but not logically related. For example: fiber facilities between the hub and the head end are not protected and are typically bundled with other node facilities. Automated or visual correlation must be able to identify those common points of failure which could affect several nodes **64**, such as a fiber cut or failure of a power supply **75** which serves all or parts of several nodes. The plant database must include knowledge of fiber for different nodes **64** sharing a common fiber bundle **66**.

[0069] d. Reports from SDI System in Support of Fault Management

[0070] Referring back to FIGS. **1-4**, SDI system **93** provides query capability that includes two primary queries. One is a query by phone number, customer **14** name, service address, or NIU **76** serial number. The returning data would be customer **14** name, service address, latitude and longitude, each NIU **76** serving that customer and associated NIU serial number, telephone number associated with each port **72** on the NIU, fiber node **64**, and HD. The second query would be a query by fiber node **64** or HDT **56**. The returning data would be a list of customers and all NIUs **76** associated with customer **14**.

Services-Specific Network Management Functions

[0071] The services-specific network management functions are those functions that are network management functions but are service-specific and are different for different services.

[0072] 1. Network Capacity Management

[0073] Capacity management is a high-priority function because HFC network **12** supports advanced services (telephony, data, and video). There are four major components for telephony capacity management: 1) fixed capacity (voice ports) based on concentration per head end modem node and NIUs **76**; 2) fixed capacity between HDT **56** and the local switch including interface group management; 3) capacity based on traffic pattern and analysis; and 4) customer reference value allocation and management. In the case of direct connect MDUs, capacity issues resolve around: 1) channel allocation, 2) transport capacity to local switch **24**, 3) capacity based on traffic pattern and analysis, and 4) customer reference value allocation and management. The major components for data capacity management include: 1) fixed capacity based on the technology platform, 2) capacity based on traffic pattern and analysis, and 3) fixed capacity between CMTSs **54** and data service providers **32**.

[0074] For telephony capacity management, SDI system **93** has telephony services modeled in its database. Based on business rules which govern the number of customers provisioned per head end modem, fixed capacity is derived. This measurement is used for example for capacity planning and for adding additional capacity to a hub.

[0075] 2. Service Assurance (Trouble Ticketing and Administration)

[0076] Trouble ticketing system **102** in conjunction with HFC network management system **16** provides for a robust and efficient service assurance capability having improvements in system to human interface, system-to-system interoperability with other trouble ticketing systems, data storage systems and technician dispatch workflow systems, and network element management systems. Primary goals include automation of all aspects of trouble ticket generation, flow management, and closure to include escalation and event notification. A short cycle implementation of easily designed and modified schemas, data field sets, and report queries that can be managed by network operator administrators meet the requirement to support a dynamic operational and business environment. A peer-to-peer distributed server architecture with synchronized data storage is used to ensure performance and redundancy as concurrent user and managed network elements scale to an estimated 1000 operators and 45 million objects respectively.

[0077] Trouble ticketing system **102** includes a rules-based trouble management system software application that maximizes operational efficiencies through field auto population, rules-based ticket workflow, user and management team maintenance of trouble, solution and script text, markets, organizations, and user data. Trouble ticketing system **102** integrates with HFC network manager **88** for automatic trouble ticket generation. HFC network manager **88** identifies and locates alarms and modifies data fields based on rules/tables, HFC network manger **88** opens and auto-populates applicable data fields, and closes a trouble ticket.

[0078] 3. Network Element Management

[0079] HFC network manager **88** communicates with element managers regarding network elements. HFC network manager **88** gathers performance, alarm, and use data from network equipment and communications facilities. HFC network manager **88** also distributes instructions to network elements so those maintenance tasks such as grooming, time slot assignment, provisioning, and inventory are performed from a central location.

HFC Network- and Services-Specific Functions

[0080] The HFC network- and services-specific functions are not separable into network related functions or services-specific functions. For example, for telephony service, the provisioning and configuration management cannot be broken out into network and services. This is because in the case of telephony service, until NIU **76** is installed, network configuration and provisioning is not complete. This is because NIU **76** is a managed network element and it is really port **72** off of the NIU that is activated during the service-provisioning process. Currently, for new service orders, the installation of an NIU **76** takes place only after the service is ordered (i.e., as a task related to service provisioning). The service configuration and provisioning takes place after NIU **76** is installed and a port **72** on the NIU is assigned for the telephony service.

[0081] 1. Configuration Management

[0082] SDI system **93** has two components for configuration management: 1) network inventory and 2) network configuration. The network inventory is the inventory of actual network equipment (physical) and the network configuration describes how that equipment is configured and connected (physical and logical). The configuration information is vital to automate the provisioning process and perform effective fault management.

[0083] SDI system **93** is an object-oriented software system that does network inventory management and design management (circuit design). SDI system **93** defines and tracks a customer's network service path from customer location to HDTs **56** (and other network elements). SDI system **93** provides strict referential integrity for network equipment, network connectivity, customer's network service path, and services that are provisioned via this network service path.

[0084] The database of SDI system **93** models HFC network **12** using a data-rule structure. The data-rule structure represents the equipment, facility and service links, and provisioned telephony customers. The data structure further represents links between HDTs **56** and fiber nodes **64**, NIUs **76**, customer location, and aggregate links from the HDTs to the NIUs at customer **14** locations. The telephony serviceable household passed (HHP) data defines the base geographic units (cable runs) in the database of SDI system **93**. The HHP data is accurately geo-coded including the relation of address location to fiber node **64**, coax cable run **68**, and latitude and longitude. The data-rule structure demonstrates the ability to capture the basic elements and relationships of HFC network **12** to support the NOC fault management process. SDI system **93** associates each telephony-ready household passed address to a fiber node **64** and coax cable bus **68** associated with this address. The database of SDI system **93** includes the data elements required to support the provisioning process and provides report capability to support network management alarm correlation and fault management.

[0085] SDI system **93** supports network inventory and topology data and acts as a configuration system that allows for changes to be made to the network. Significant changes to the network can be entered through a batch load process and small changes can be entered using a GUI interface. The data is needed from various sources such as engineering data (equipment and cable links), HHP data along with association of house to fiber node **64** and coax cable bus **68** it is served by, and data associated with customers **14** that were provisioned prior to SDI system deployment. The HHP data includes house key, address, latitude, longitude, fiber node **64**, coax cable bus **68**, hub **52** number, power supply **75**, etc. The equipment location data includes location for fiber nodes **64** and hubs **52** with addresses, latitudes, and longitudes. The equipment data includes equipment profiles and equipment inventory such as HDTs **56**, fiber nodes **64**, forward and return paths, etc. The network cabling data includes data determined by system architecture and actual cabling inventory and includes relationships of node/forward path/reverse paths, laser transmitters and receivers, and power supplies. The network aggregate link data is based on equipment, cable inventory, and network architecture.

[0086] Referring now to FIG. **8**, a highly detailed view of HFC network management system **16** within a broadband network environment is shown. In general, the applications of HFC network management system **16** normalize many of the variables that exist in HFC network **12** so as to allow the definition and support of provisioning and maintenance interfaces to the service management layers. The interfaces and set of service delivery processes and functions established are reusable for telephony, data, and video services because the same set of functions need to occur and only the rules are different based on the service-enabling network elements. This implies that any network management system application desirably is an object-based, component architecture solution which is rules- and tables-driven to provide the flexibility and scale to address a high-capacity multiple-services network element environment. The goal of HFC network management system **16** is to integrate and automate system support such that human intervention is minimally needed.

[0087] FIG. **8** represents a set of component systems and interfaces that are necessary to achieve integrated network management and automated HFC provisioning, automated trouble ticket generation, and automated fault management capabilities in a broadband network **10** having an HFC network **12**. As introduced above, these are three key network management functions performed by HFC network management system **16**.

[0088] The first key network management function is the automation of HFC provisioning. For example, after a customer service representative **153** takes an order for telephony service provisioning of the telephony service begins. The provisioning of a customer's telephone service has two primary considerations. The first consideration is to provision a logical HFC circuit connecting the appropriate CPE **76** to the corresponding appropriate head end office (HDT **56**). The second consideration is provisioning a local switch **24** that delivers dial tone and features. Automation of HFC network provisioning means without manual intervention. As shown in flowchart **260** of FIG. **9**, this translates into receiving an order from an order manager **142** as shown in block **262**, assigning appropriate HFC network elements for that order as shown in block **264**, generating a line equipment number (LEN) as shown in block **266**, and sending the LEN back to the order manager (as shown in block **268**) that can use the LEN to provision the local switch in conjunction with service provisioning systems **28** as shown in block **270**.

[0089] The HFC service provisioning includes the assignment of HFC network components as shown in block **164** to create a logical circuit connecting the CPE to the corresponding appropriate hub office equipment. This includes traversing the various coax bus, fiber node, fiber path, and hub office equipment. The automation of HFC provisioning depends on the HFC network configuration data being readily available. The database of SDI system **93** supports automated provisioning by storing existing HFC network topology. The database of SDI system **93** has the ability to maintain a referential integrity of network equipment, network connectivity, and logical service paths associated with customer services.

[0090] Order manager **142** provides workflow control for the ordering and interactions with other processes such as billing and dispatch provided by dispatch manager **42**. SDI system **93** is notified of an order request via an interface with order manager **142**. SDI system **93** will transfer the order request to HFC network manager **88** which in turn then interfaces to HDT network element manager **146**. HDT network element manager **146** then executes the provisioning commands.

[0091] There are five separate areas that should be automated to achieve fully automated designs in SDI system **93**. The first is order creation entry of order data into the database

of SDI system **93** which is performed by an interface to order manager **142** for full automation. The second is design—selection of the components (NIU **76**, HDT **56**, etc.). The third is implementation—sending HDT/HEM to the HDT network element manager **146**, sending the LEN to order manager **142**, and test data (from the HDT network element manager). The fourth is interfaces for systems such as SDI system **93**, HFC network manager **88** can take an SDI system request and turn it into a sequence of commands necessary for provisioning a particular service on a particular piece of equipment. The fifth is broadband development—sequences of HFC network manager **88** that allow a single calling point to execute desired functions such as add new service, modify existing service, and delete service. This is required for each desired function in each particular piece of equipment.

[0092] Referring now back to FIG. **8**, the second key network management function is automated trouble ticket creation. The following is a list of capabilities for accomplishing the goal of auto trouble ticket creation: data feed from fault manager **90** into outage tables of trouble ticket system **102**; integration with customer service representative tools for enhanced automated rules-based diagnostic testing, capture, and auto-population of diagnostic information into appropriate data fields; integration with SDI system **93** via HFC network manager **88** to provide wide-scale and drill down system outage alert and notification for enhanced trouble correlation; an interface to include simple diagnostic tool interface and auto trouble ticket generation/assignment based on diagnostic results and rules/tables.

[0093] The third key network management function is automated fault management. HFC status monitoring **144** of HFC network manager **88** monitors HFC network **12** for configuration and problem status. Similarly, network element manager **146** of HFC network manager **88** monitors service network element **56** (i.e., HDT, CMTS, and video equipment) for configuration and problem status. HFC network manager **88** generates alarm data if there are any problems. Fault manager **90** uses the alarm data in conjunction with the network configuration data stored in the database of SDI system **93** to generate a graphical display of the location and type of problems.

[0094] Referring now to FIG. **10** and with continual reference to FIGS. **2**, **5**, **6**, and **7**, a block diagram **150** describing the architecture of AVT **90** and associated data flow is shown. As described above, AVT **90** provides graphical visualization of HFC network **12** and service alarms. This alarm visualization capability assists network operations center (NOC) **94** in the trouble sectionalization, isolation, and resolution process. In general, AVT **90** provides geographic displays with varying zoom levels, from country to neighborhood and street and household levels, overlaid with fiber node **64** boundary, distribution cable plant **68** layout, and equipment at single-dwelling unit (SDU) and multiple-dwelling unit (MDU) premises. The geographic displays also represent head end **52** locations, associated hubs, secondary hubs, fiber nodes **64**, and fiber layer **66** between them.

[0095] Alarm and status information is shown via color codes and icons represent equipment. Through these geographic displays NOC **94** can visually correlate event information. To help further in the trouble isolation process, operators can access diagnostic tools and obtain reports about customer **14**, the service, and the equipment.

[0096] AVT **90** focuses on the fault management functional area of HFC network **12** operations. Manual correlation of information available from network elements is currently used to isolate problems. This method, while demonstrative of the effectiveness of correlation, is time consuming and may result in details being overlooked due its manual nature. Enhanced correlation methods for fault management can be obtained through combining automated, visual, and cross-product correlation of customer-related problems and network element status information. By developing a system that can present this information in an automated user-friendly fashion operators can correlate problems in HFC network **12** due to their root cause and location.

[0097] AVT **90** focuses on the visual correlation and includes the following components: a graphical visual display system to accurately display street maps of the market regions that have been overlaid with HFC cable plant **68** diagrams, color-coded dynamic alert information representing type of service, status of intelligent network elements, and the customer reported problems; and geo-coded network elements and customer service addresses that enable symbols to be accurately displayed on maps relative to streets and physical plant.

[0098] AVT **90** provides NOC **94** with the ability to rapidly identify telephony, data, video, and VoIP alarms, communicate the type of alarm and location of the alarm, and track the resolution of the alarms to provide superior customer service. One objective of AVT **90** is to maximize the efficiency and effectiveness of NOC **94** in identifying HFC network and supported service-affecting alarms, and correlating these alarms to customer proximity, plant and equipment proximity, and connectivity proximity for the resolution of alarms, problems, and customer service. This objective is accomplished by: 1) consolidating alarm data, location and connectivity data, and spatial data from separate databases; 2) visually representing this consolidated information in a geographic format on a map (point on a map); and 3) displaying SDI system reports for the selected SDI system point (i.e., providing the underlying data behind the point on a map as requested). In summary, AVT **90** creates a map which enables underlying data from several databases to visually represent an alarm, customer proximity, plant and equipment, and HFC network connectivity pinpoints and to summarize this information.

[0099] As shown in FIG. **10**, AVT **90** is located on a web server and is operable with a spatial database **152** for receiving data stored in several databases. Spatial database **152** receives alarm data from an HFC network manager status database **154**. HFC network manager **88** monitors HFC network **12** and provides the alarm data to HFC network manager status database **154**. HFC network manager status database **154** converts the alarm data from HFC network manager **88** into data ready to be used by spatial database **152**. SDI system **93** provides provisioning (for example, location and connectivity data) data indicative of the logical relationship between various network elements and the service address information to spatial database **152** for the alarm data correlation processing. SDI system **93** also produces customer affecting reports for AVT **90**. Geographical/spatial data is available for spatial database **152** as a reference source to convert the service address to geographical coordinates. A landbase database **156** provides the geographic data to spatial database **152**. An HFC engineering database **158** provides equipment layout data to spatial database **152** and a household passed database **160** provides household passed data to

the spatial database. AVT user interface **162** is the graphical display system for displaying the alarms and the related information on electronic maps.

[0100] The following table describes the various data sources and types of data interchanged among the elements involved with AVT **90**.

From	Data Category and Items
HFC network manager 88	Alarm data: NIU 76, fiber node 64, and power supply 75 alerts.
SDI system 93	Location and connectivity data (reports)/ Report elements: customer name, customer address, location (latitude/longitude), power supply, node #, voice port/RSU serial #, HDT #, DMC #, HEM#, and phone #.
landbase database 156	Geographic data
HFC engineering database 158	Engineering plant data
Household passed database 160	Household passed data.

[0101] The following table describes the data that is displayed by AVT **90**.

Data Category	Data Items
Geographical information	Land base and engineering plant.
Alarms	Critical, major, and minor. Alarm color code will follow the following standard. Clear: normal icon (outline). Informational: magenta. Warning: blue. Minor: yellow. Major: orange. Critical: red.
Alarm related underlying data	SDI system reports.
Alarm related information	Device name as provided by HFC network manager 88. Equipment type description (e.g., NIU (Voice Port/RSU), node). Alarm severity. Time stamp of alarm occurrence. Latitude/longitude of location of problem. Customer name, address, and telephone number (if the alarmed equipment is CPE).

[0102] 1. AVT Alarm Displays—Alarm Data

[0103] AVT **90** provides displays of the following types of HFC network alarms: NIU **76** (voice port/RSU) alerts, fiber node **64** alerts, and power supply **75** alerts. AVT **90** allows operators to select an alarmed network element and access HFC network manager **88** for alarm details associated with that network element. From a map display, AVT **90** allows operators to list the alarm information available at spatial database **152** for a selected network element in order to assist operators in investigating some particular alarm condition. The available alarm information includes the alarm-related information listed in the table above. AVT **90** further allows operators to obtain element name mapping tables in order to obtain name conversions for network elements named differently by the various alarm and configuration data sources. In effect, operators are able to query a network element name and have all other names associated with the network element displayed. AVT **90** uses the following information from spatial database **152** for the alarm displays: node boundary, landbase, and engineering plant. AVT **90** provides the ability to display the following underlying landbase data with the same orientation: road edge, roads, street names and text labels, states, counties, cities, hydrology, parks, urban boundaries, property parcels, and railroads.

[0104] AVT **90** includes the ability to display the following reports generated by SDI system **93**: 1) customer service/equipment query; 2) equipment impacted by power alarm; 3) customers impacted by alarmed equipment; 4) HFC telephony provisioning work order; and 5) location, equipment, and services by house key.

[0105] 2. AVT Alarm Displays—Alarm Characteristics

[0106] AVT **90** depicts equipment, alarms, and status information with consistent and reasonably descriptive representations. The display of equipment, alarms, and status information by AVT **90** uses representations and colors that are consistent throughout the AVT and other related applications. AVT **90** includes the capability to pan and zoom in and out while displaying appropriate details of the layer based on the selected zoom factor. The scale and shape of icons on the display of AVT **90** corresponds with the street to market level zoom level so that individual icons can remain visible without occupying the entire display. AVT **90** aggregates all icons within a node boundary into a single circular dot for each fiber node **64** boundary at the market level view. From the dot, an operator is able to access the attribute information for the corresponding fiber node **64**. AVT **90** aggregates all icons related to a hub and equipment served by the hub into a single circular dot at the country level view. AVT **90** uses consistent text abbreviations to indicate the alarm severity where needed. AVT **90** updates the displays autonomously when changes to the alarm information shown within a visible area arrives.

[0107] 3. AVT Alarm Displays—Default Settings for Functional Groups

[0108] The default settings for functional groups are intended to allow an operator to select a functional group which defines a map view that is displayed when the operator starts the AVT **90**. The functional group will also determine default map layer settings. AVT **90** allows administrators to define functional group profiles. The functional group profile includes the name of the functional group, home map view, and default layers. For example, the default layers include alarm points, node equipment, node boundary, telephony CPE, and telephony hub equipment.

[0109] 4. AVT Alarm Displays—Navigation Aids

[0110] The navigation aids described here augment the zoom and pan controls and are intended to allow operators to maneuver to particular information directly without having to pan or traverse various zoom layers. AVT **90** includes a "find equipment" function providing a mechanism for operators to type in information (e.g., NIU serial number, home address, and HDT equipment name) resulting in the display to center on the identified element with the element visible. AVT **90** includes a "find node" function providing a mechanism for operators to type in a node ID resulting in the display to zoom to a view that shows the fiber node and the associated fiber node boundary. AVT **90** includes a "find hub" function that allows operators to navigate to the view depicting the hub and fiber nodes served by the hub. AVT **90** is able to navigate from an alarm representation at an aggregate display to the view depicting the equipment associated with that alarm. AVT **90** includes the following display layers: alarm points (geocoded alarms represented as circular dots on the display),

alarm polygons (geographical area impacted by an alarm point), fiber node **64** equipment, power supply **75**, fiber node boundary (geographical area served by a fiber node), fiber plant **66** (fiber component of the HFC network, from the fiber nodes to head end **52**, that carries the optical signals both upstream and downstream), coax plant **68** (coaxial component of the HFC network, from the fiber nodes to CPE **74**, that carries the electrical signals both upstream and downstream), landbase (basic geographical mapping data on which engineering data is overlaid), property parcels (property boundaries included in the landbase), telephony CPE (NIU **76**), and telephony hub equipment. AVT **90** further allows operators to print and save images of the current map display.

[0111] Referring now to FIG. **11**, a block diagram of AVT **90** within a first HFC network management configuration **170** is shown. First configuration **170** supports fault management with respect to telephony services. Within first configuration **170**, AVT **90** represents aggregate head end, primary hub, second hub, and fiber node **64** locations and the connectivity between them in order for an operator to see possible relationships between alarms posted against these locations. Attribute information for HDT **56** is displayed by AVT **90**. The attribute information of HDT **56** includes equipment type, equipment description, equipment ID, and element manager. SDI system **93** provides the attribute information to AVT **90**. AVT **90** allows operators to access equipment displays for HDTs **56** deployed at a head end **52**. The display of HDT **56** deployed at a head end **52** shows shelf/card level configuration information along with an indication of the most severe alarm associated with each equipment and card. To determine the impact of a particular HDT **56** alarm, AVT **90** allows operators to access "impacted customer" reports from SDI system **93**. After selecting a particular alarm associated with HDT **56**, operators are able to request a printable listing of customers impacted by the alarm, sorted by customer phone number, showing NIU/RSU identification, customer name, and customer phone number.

[0112] The attribute information for network and CPE elements includes the corresponding latitude and longitude. When multiple, concurrent alarms are associated with an icon, AVT **90** color-codes the icon with the highest severity alarm and also show an indication that more alarms are associated with that icon. AVT **90** allows operators to list the currently active alarms associated with an icon in reverse chronological order.

[0113] From the map display AVT **90** allows operators to list the telephony alarm information available at spatial database **152** for a selected network element. The available telephony alarm information includes device name as provided by HFC network manager **88**, equipment type description (e.g., HDT **56**, NIU/RSU **76**, fiber node **64**), alarm severity, time stamp of alarm occurrence, alarm state (acknowledged or not acknowledged), and customer name and telephone number (if the alarmed equipment is CPE). AVT **90** allows operators to access alarm details associated with a selected network element.

[0114] AVT **90** provides a visually changed representation of the acknowledged alarms to notify operators that someone is working on the particular trouble. AVT **90** also allows operators to acknowledge the alarms. AVT **90** allows operators to define functional group profiles including name of functional group, home map view, and default display layers. The default display layers include alarm points, trouble tickets, alarm polygons, fiber node equipment and boundaries, fiber plant **66**, coax plant **68**, landbase, property parcels, CPE **74**, **76**, and **78**, and HDT **56** (and HSD, CPE, and HSD head end equipment as described with respect to FIG. **12**).

[0115] AVT **90** provides a find equipment function that allows operators to navigate to the view depicting the selected equipment. Operators can enter equipment information (e.g., CPE serial number, home address, HDT name) resulting in the display to center on the identified element with the element visible. (As described with respect to FIG. **12**, the equipment-identifying information includes domain name or IP address of CMTS equipment **54** and IP address of MAC address of cable modems **74**.)

[0116] AVT **90** provides a find node function that allows operators to navigate to the view depicting fiber node **64** and fiber node boundary. The find node function provides a mechanism for operators to type in a fiber node **64** ID resulting in the display zooming to a view that shows the node and associated fiber node boundary.

[0117] AVT **90** provides a find head end function that allows operators to navigate to the view depicting the head **52** end and fiber nodes **64** served by that head end. AVT **90** also allows operators to navigate from an alarm representation at an aggregate display to the view depicting the equipment associated with that alarm.

[0118] Referring now to FIG. **12**, a block diagram of AVT **90** within a second HFC network management configuration **180** is shown. Second configuration **180** supports fault management with respect to telephony, data, and video services. Second configuration **180** includes integrating trouble ticket indicators into the visual trouble isolation environment to assist operators in the recognition of trouble ticket patterns, clusters, and relationships of trouble tickets to autonomously reported HFC network alarms.

[0119] Within second configuration **180**, AVT **90** is able to show via a special icon that one or more trouble tickets have been posted in trouble ticket system **102** against a particular network element (e.g., CPE **74**, **76**, and **78**, HDT **56**, CMTS **54**, etc.). This allows operators to know that an alarm and trouble ticket is associated with certain equipment. In order to indicate that multiple, concurrent trouble tickets are posted against a network element, AVT **90** uses a similar method as showing multiple alarms posted against a network element. The trouble ticket indicator reflects the highest priority trouble ticket and some indication that multiple, concurrent trouble tickets exist. Operators are able to obtain a list of these concurrent trouble tickets showing trouble ticket numbers, status, and priority in reverse chronological order by ticket start time/date. From the displayed trouble ticket indicator, AVT **90** allows operators access to trouble ticket related information stored in spatial database **152**. This information includes equipment name/ID (or customer name if the trouble ticket is not associated with equipment and includes customer information), trouble ticket number, trouble ticket category, date and time of trouble start, and ticket priority.

[0120] AVT **90** provides a find trouble ticket function that allows operators to navigate to the view depicting the requested trouble ticket. AVT **90** represents the trouble ticket priority on the displays by color-coding the trouble ticket indicator (e.g., icon) using the same colors used to show alarm severity. From the map display, operators can obtain a printable listing of trouble tickets (trouble ticket information to be printed for each trouble ticket) contained within a selected area.

[0121] Second configuration **180** is intended to support trouble isolation of HFC network **12** which provides data and video services in addition to telephony services. Providing a common trouble ticket isolation environment for telephony, data, and video services will increasingly become more important as service markets overlap. AVT **90** assists in identifying HFC network problems impacting all of these services rather than replicated service for each market thereby facilitating single trouble shooting and resolution activities. As for telephony markets, visualizing data- and video-related trouble tickets on map displays is expected to help operators recognize potential problems within the service provider's infrastructure. The representation of and access to data- and video-related information via AVT **90** is intended to be consistent with the representation of and access to telephony-related information.

[0122] With respect to cable modems **74** at customer-premises **14**, AVT **90** displays detailed views of home locations which identify cable modems and depict the cable modem's alarm severity and status. AVT **90** depicts cable modems **74** at customer-premises **14** location using a separate symbol than currently used for the NIU/RSU **76**. The representation of alarm severity follows the same color-coding as described for the telephony services. Also, the alarm status (acknowledged or not acknowledged) is represented as described for the telephony services. The mechanisms for multiple concurrent alarms and access to alarm detail information is the same for telephony equipment.

[0123] Attribute information for cable modems is accessible via AVT **90** and includes cable modem's **74** IP address. The database of SDI system **93** inventories cable modem's **74** IP address. AVT **90** allows operators to access customer, service, and upstream connectivity reports associated with a customer's **14** cable modem **74** from SDI system **93**. AVT **90** allows operators to access cable modem-related reports from SDI system **93** similar to the telephony services. The report information includes customer name, address, phone number, ISP login, service, IP address of cable modem **74**, and upstream connectivity. AVT **90** provides context-sensitive access to cable modem **74** and CMTS **54** diagnostic functions.

[0124] Attribute information for CMTS **54** is accessible via AVT **90** and includes equipment type, equipment domain name, IP address, and element manager. The database of SDI system **93** inventories the information of CMTS **54**. From the map displays AVT **90** provides configuration information for a selected CMTS **54**. The CMTS configuration information includes configured Ethernet interfaces facing the router toward the regional data center, configured upstream cards facing HFC network **12** and customer **14**, configured cable modems **74** (IP and MAC address) per CMTS **54** upstream card. Per cable modem **74** the information includes node name, customer name, address, phone, and customer login. In order to determine the impact of a particular CMTS **54** alarm, AVT **90** allows operators to access impacted customer reports from SDI system **93**.

[0125] Referring now to FIG. **13**, a block diagram of AVT **90** within a third HFC network management configuration **190** is shown. Within third configuration **190**, AVT **90** is operable with HFC network manager **88** and trouble ticket system **102** to provide operators with the means to launch trouble tickets with auto-populated equipment and alarm information. AVT **90** displays maps that allow operators to select specific equipment (e.g., HDT **56**, CMTS **54**, NIU **76**, cable mode **74**, etc.) and create a trouble ticket with relevant data auto-populated. Such data includes equipment data, alarm status, and operator information. The trouble tickets created via AVT **90** are consistent with trouble tickets launched from the alarm originating system (HFC network manager **88**) allowing trouble ticket system **102** to detect possibly redundant trouble tickets at the time of creation.

[0126] Referring now to FIG. **14**, a block diagram of a fourth HFC network management configuration **200** is shown. Within fourth configuration **200**, AVT **90** is operable with a correlation system **202** for representing correlated alarms. The primary focus of correlation system **202** is to correlate, aggregate, and redistribute event information from multiple sources to operators. The mechanisms to deliver correlated information to operators includes a common event list for trouble identification and prioritization that allows event displays filtered by criteria such as per market or multiple markets and services.

[0127] Thus it is apparent that there has been provided, in accordance with the present disclosure, a method and system for generating visual displays of hybrid fiber coax (HFC) network data that fully satisfy the objects, aims, and advantages set forth above. It is to be understood that the method and system in accordance with the present disclosure may be used to manage other broadband networks providing multiple services such as fixed wireless networks. While the present disclosure has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives.

[0128] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not be to interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

What is claimed is:

1. A system comprising:

a hybrid fiber coax (HFC) network having network elements operable for communicating telephony, data, and video signals with customer-premises equipment of subscribers;

an HFC network manager operable for monitoring status and the configuration including the assigned capacity of the network elements and for generating alarm data indicative of improper status or configuration of the network elements;

a service, design, and inventory (SDI) database operable with the HFC network manager for storing data indicative of the status and the configuration of the network elements and for storing data indicative of physical and logical connections between the network elements and the customer-premises equipment; and

a fault manager having an alarm visualization tool operable with the HFC network manager and the database for generating visual displays of the status and configuration including the assigned capacity of the network elements overlaid with the alarm data and overlaid with the physical and logical connections between the network elements and the customer-premises equipment based on the stored data.

2. The system of claim **1** further comprising:

a landbase database for storing data indicative of geography of the HFC network, wherein the alarm visualization tool is operable with the HFC network manager, the SDI database, and the landbase database for generating the visual displays further overlaid with the geography of the HFC network.

3. The system of claim **1** further comprising:

an HFC network engineering database for storing data indicative of engineering layout of the HFC network, wherein the alarm visualization tool is operable with the HFC network manager, the SDI database, and the HFC network engineering database for generating the visual displays further overlaid with the engineering layout of the HFC network.

4. The system of claim **1** further comprising:

a household passed database for storing data indicative of households passed in the HFC network, wherein the alarm visualization tool is operable with the HFC network manager, the SDI database, and the household passed database for generating the visual displays further overlaid with the households passed in the HFC network.

5. The system of claim **1** wherein:

the network elements include a host digital terminal (HDT) for communicating the telephony signals, a cable modem termination system (CMTS) for communicating the data signals, and video equipment for communicating the video signals, wherein the network elements further include a fiber optics node connected at one end to the HDT, the CMTS, and the video equipment by a fiber optics network and connected at the other end to the customer-premises equipment by coax.

6. The system of claim **1** wherein:

the alarm visualization tool generates visual displays of the alarm data via at least one of color codes and icons representing the network elements and the customer-premises equipment.

7. The system of claim **1** wherein:

the SDI database is operable to generate an SDI report for at least one of a network element and a customer-premises equipment, the report including information about the at least one network element and the customer-premises equipment, wherein the alarm visualization tool is operable for the displaying SDI reports for a selected network element and customer-premises equipment on the visual displays.

8. The system of claim **1** further comprising:

a trouble ticket generator operable for generating trouble ticket alerts in response to improper status of at least one of the network elements and the customer-premises equipment, wherein the alarm visualization tool is operable with the trouble ticket generator for displaying the trouble ticket alerts for the at least one of the network elements and the customer-premises equipment having improper status on the visual displays.

9. The system of claim **8** wherein:

the alarm visualization tool is operable with HFC network manager and the trouble ticket generator for generating trouble ticket alerts with auto-populated status information.

10. The system of claim **1** further comprising:

a correlator for correlating data including trouble ticket alerts generated by the trouble ticket generator and the status of the network elements and the customer-premises equipment, wherein the alarm visualization tool displays the correlated data on the visual displays.

11. A system comprising:

a hybrid fiber coax (HFC) network having network elements operable for communicating telephony, data, and video signals with customer-premises equipment of subscribers;

an HFC network manager operable for monitoring status of the network elements and the customer-premises equipment of subscribers, for monitoring the configuration including the assigned capacity of the network elements and the customer-premises equipment, and for generating alarm data indicative of improper status or configuration of the network elements and the customer-premises equipment;

a service, design, and inventory (SDI) database operable with the HFC network manager for storing data indicative of the status and the configuration of the network elements and the customer-premises equipment and for storing data indicative of physical and logical connections between the network elements and the customer-premises equipment; and

a fault manager having an alarm visualization tool operable with the HFC network manager and the database for generating visual displays of the status and configuration including the assigned capacity of the network elements and the customer-premises equipment overlaid with the alarm data and overlaid with the physical and logical connections between the network elements and the customer-premises equipment based on the stored data.

12. The system of claim **11** wherein:

the network elements include a host digital terminal (HDT) for communicating the telephony signals, a cable modem termination system (CMTS) for communicating the data signals, and video equipment for communicating the video signals, wherein the network elements further include a fiber optics node connected at one end to the HDT, the CMTS, and the video equipment by a fiber optics network and connected at the other end to the customer-premises equipment by coax.

13. The system of claim **11** wherein:

the alarm visualization tool generates visual displays of the alarm data via at least one of color codes and icons representing the network elements and the customer-premises equipment.

14. The system of claim **11** wherein:

the SDI database is operable to generate an SDI report for at least one of a network element and a customer-premises equipment, the report including information about the at least one network element and the customer-premises equipment, wherein the alarm visualization tool is operable for the displaying SDI reports for a selected network element and customer-premises equipment on the visual displays.

15. The system of claim **11** further comprising:

a trouble ticket generator operable for generating trouble ticket alerts in response to improper status of at least one of the network elements and the customer-premises equipment, wherein the alarm visualization tool is operable with the trouble ticket generator for displaying the trouble ticket alerts for the at least one of the network elements and the customer-premises equipment having improper status on the visual displays.

16. The system of claim **15** wherein:

the alarm visualization tool is operable with HFC network manager and the trouble ticket generator for generating trouble ticket alerts with auto-populated status information.

17. The system of claim **11** further comprising:

a correlator for correlating data including trouble ticket alerts generated by the trouble ticket generator and the status of the network elements and the customer-premises equipment, wherein the alarm visualization tool displays the correlated data on the visual displays.

18. A method for a hybrid fiber coax (HFC) network provided with network elements operable for communicating telephony, data, and video signals with customer-premises equipment of subscribers, the method comprising:

monitoring status of the network elements;

monitoring the configuration including the assigned capacity of the network elements;

generating alarm data indicative of improper status or configuration of the network elements;

storing data indicative of the status and the configuration of the network elements;

storing data indicative of physical and logical connections between the network elements and the customer-premises equipment; and

generating visual displays of the status and configuration including the assigned capacity of the network elements overlaid with the alarm data and overlaid with the physical and logical connections between the network elements and the customer-premises equipment based on the stored data.

19. The method of claim **18** further comprising:

generating trouble ticket alerts in response to improper status of at least one of the network elements and the customer-premises equipment, wherein generating visual displays includes displaying the trouble ticket alerts for the at least one of the network elements and the customer-premises equipment having improper status on the visual displays.

20. The method of claim **19** further comprising:

generating trouble ticket alerts with auto-populated status information.

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