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Samba

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(45) **Date of Patent: Oct. 21, 2014**

(54) **APPARATUS AND METHODS FOR REAL-TIME MULTIMEDIA NETWORK TRAFFIC MANAGEMENT AND CONTROL IN WIRELESS NETWORKS**

(75) Inventor: **Augustine S. Samba**, Aurora, OH (US)

(73) Assignee: **Kent State University**, Kent, OH (US)

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(22) Filed: **Jun. 10, 2010**

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Related U.S. Application Data

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G06F 15/16	(2006.01)
H04L 12/24	(2006.01)
H04L 12/26	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 41/5009*** (2013.01); *H04L 41/0213* (2013.01); *H04L 43/0894* (2013.01); ***H04L 41/5054*** (2013.01); ***H04L 41/06*** (2013.01)

USPC **709/224**; 709/223

(58) **Field of Classification Search**

USPC 709/223–226

See application file for complete search history.

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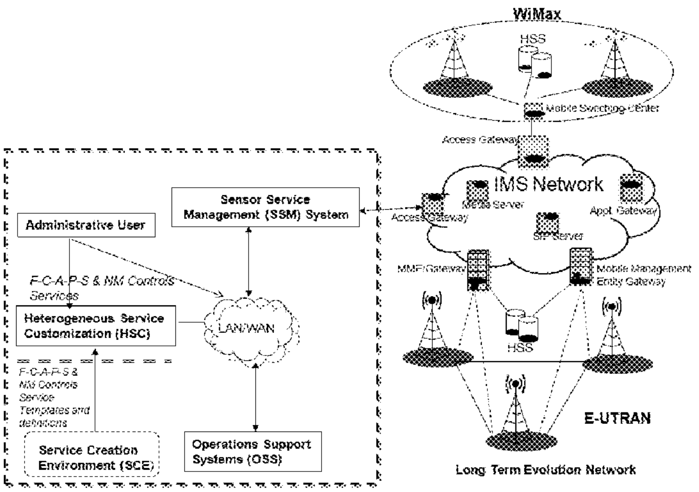
Primary Examiner — Yasin Barqadle

(74) *Attorney, Agent, or Firm* — Hahn Loeser + Parks LLP; Scott M. Oldham, Esq.

(57) **ABSTRACT**

The invention is directed to network management systems and methods that provide substantially real-time network management and control capabilities of multimedia streaming traffic in telecommunications networks. The invention provides pre-emptive and autonomous network management and control capabilities, and may include shared intelligence of embedded systems—Heterogeneous Sensor Entities (HSE) and the Sensor Service Management (SSM) system. HSEs are distributed real-time embedded systems provisioned in various network elements. HSEs performs fault, configuration, accounting, performance and security network management functions in real-time; and real-time network management control activations and removals. SSM facilitates automated decision making, rapid deployment of HSEs and real-time provisioning of network management and control services. The service communication framework amongst various HSEs and the SSM is provided by the Heterogeneous Service Creation system. The proposed network management procedure provides real-time network management and control capabilities of multimedia traffic in wireless networks and clusters of independent networks respectively.

22 Claims, 19 Drawing Sheets


WiMax
HSS
Mobile Switching Center
Access Gateway
IMS Network
Media Server
Appl. Gateway
Access Gateway
SIP Server
MMF/Gateway
Mobile Management Entity Gateway
HSS
E-UTRAN
Long Term Evolution Network
Sensor Service Management (SSM) System
Administrative User
F-C-A-P-S & NM Controls Services
Heterogeneous Service Customization (HSC)
LAN/WAN
F-C-A-P-S & NM Controls Service Templates and definitions
Service Creation Environment (SCE)
Operations Support Systems (OSS)

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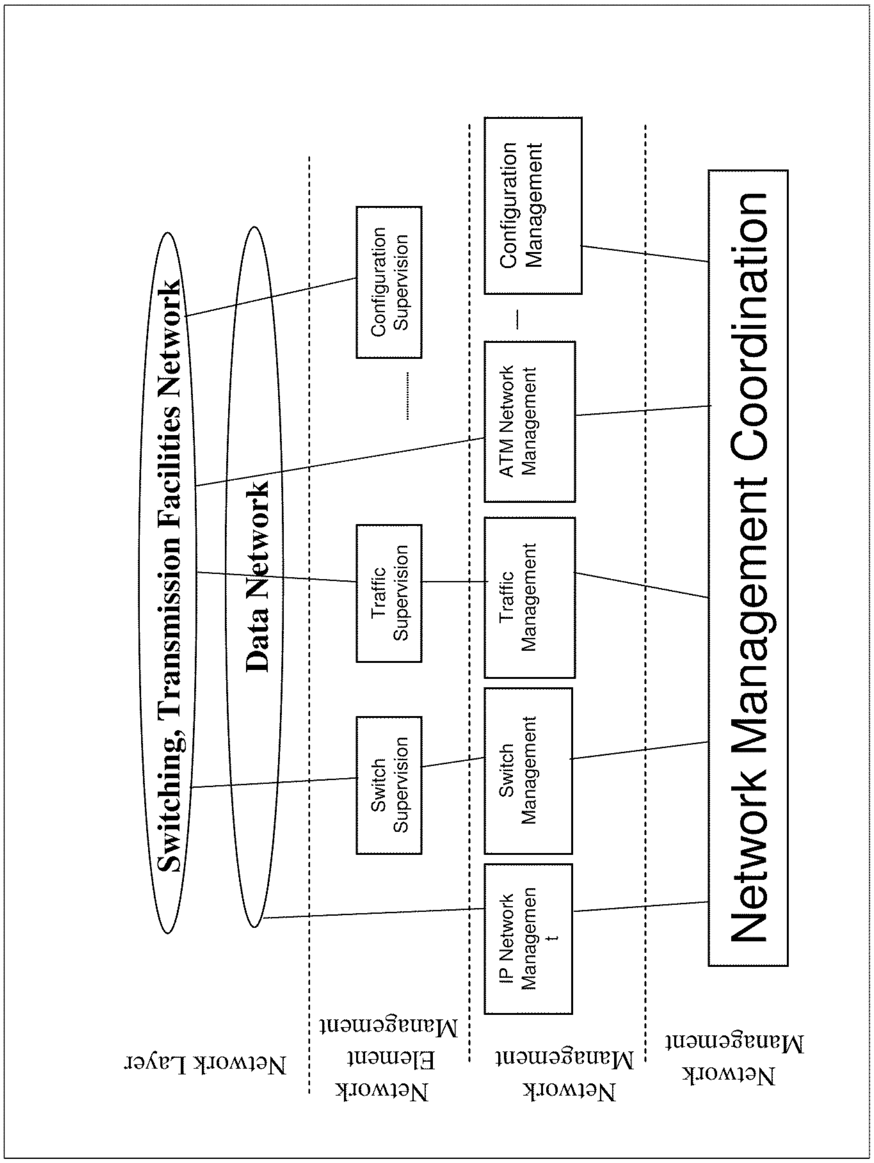
Switching, Transmission Facilities Network
Data Network
Configuration Supervision
Traffic Supervision
Switch Supervision
Configuration Management
ATM Network Management
Traffic Management
Switch Management
IP Network Managemen t
Network Management Coordination
Network Layer
Network Element Management
Network Management
Network Management

Figure 1(a)

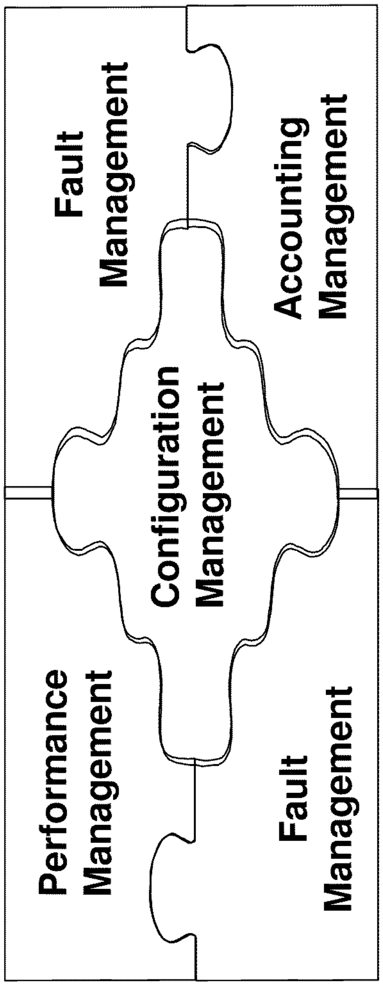
Performance Management
Fault Management
Configuration Management
Fault Management
Accounting Management

Figure 1 (b)

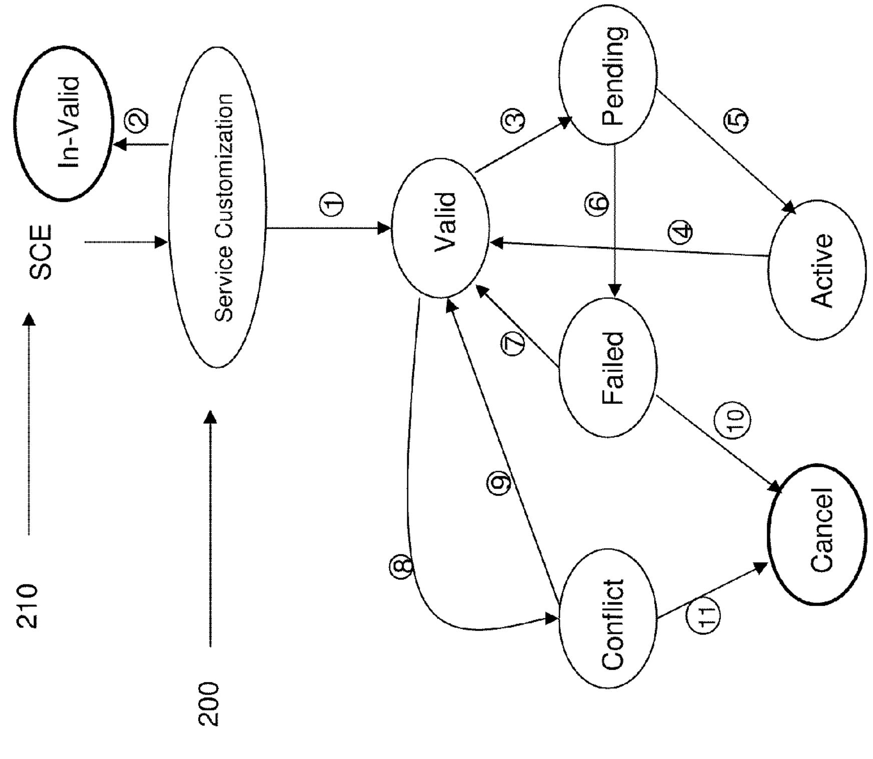
210
200
SCE
In-Valid
Service Customization
Valid
Pending
Active
Failed
Conflict
Cancel
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪

Figure 2

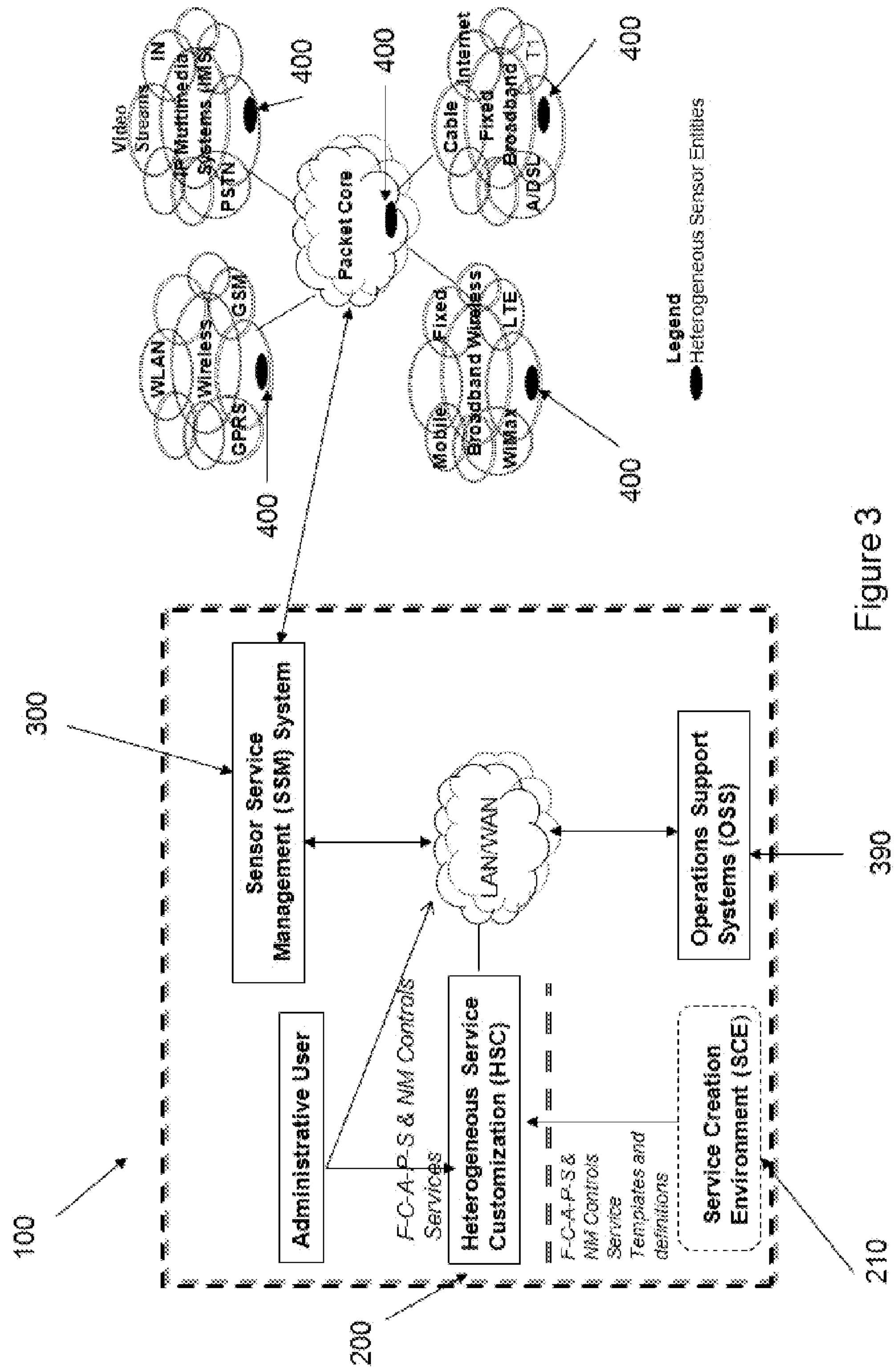
100
200
210
300
390
400
400
400
400
400
Administrative User
F-C-A-P-S & NM Controls Services
Heterogeneous Service Customization (HSC)
F-C-A-P-S & NM Controls Service Templates and definitions
Service Creation Environment (SCE)
Sensor Service Management (SSM) System
LAN/WAN
Operations Support Systems (OSS)
Packet Core
WLAN
Wireless
GPRS
GSM
Video Streams
IN
IP Multimedia Systems (IMS)
PSTN
Cable
Internet
Fixed Broadband
T1
A/DSL
Mobile
Fixed
Broadband Wireless
WiMax
LTE
Legend
● Heterogeneous Sensor Entities

Figure 3

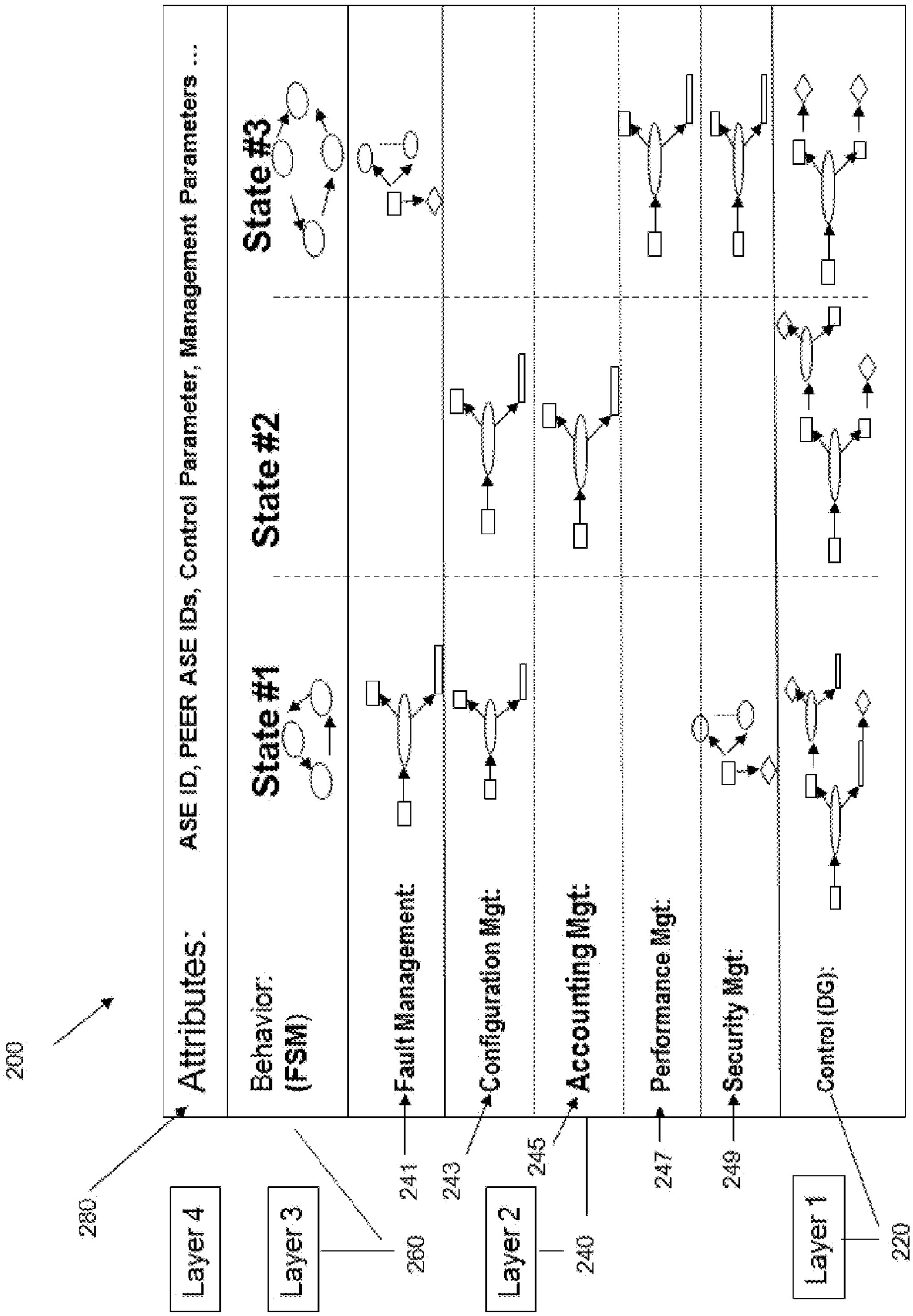
200
Attributes:
ASE ID, PEER ASE IDs, Control Parameter, Management Parameters ...
Behavior:
(FSM)
State #1
State #2
State #3
Fault Management:
Configuration Mgt:
Accounting Mgt:
Performance Mgt:
Security Mgt:
Control (DG):
280
Layer 4
Layer 3
260
241
243
245
Layer 2
240
247
249
Layer 1
220

Figure 4

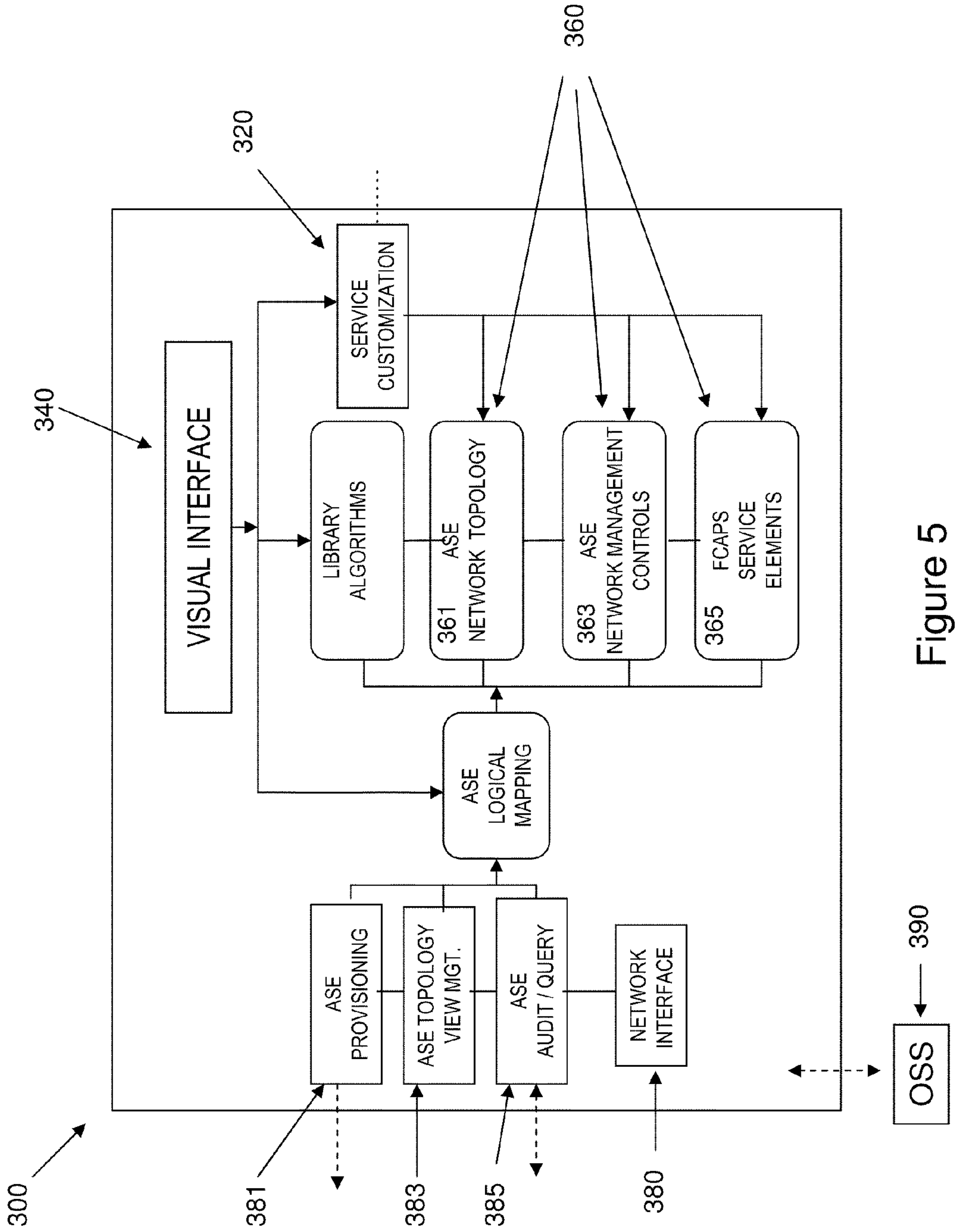
360
320
340
VISUAL INTERFACE
SERVICE CUSTOMIZATION
LIBRARY ALGORITHMS
361 ASE NETWORK TOPOLOGY
363 ASE NETWORK MANAGEMENT CONTROLS
365 FCAPS SERVICE ELEMENTS
ASE LOGICAL MAPPING
ASE PROVISIONING
ASE TOPOLOGY VIEW MGT.
ASE AUDIT / QUERY
NETWORK INTERFACE
390
OSS
300
381
383
385
380

Figure 5

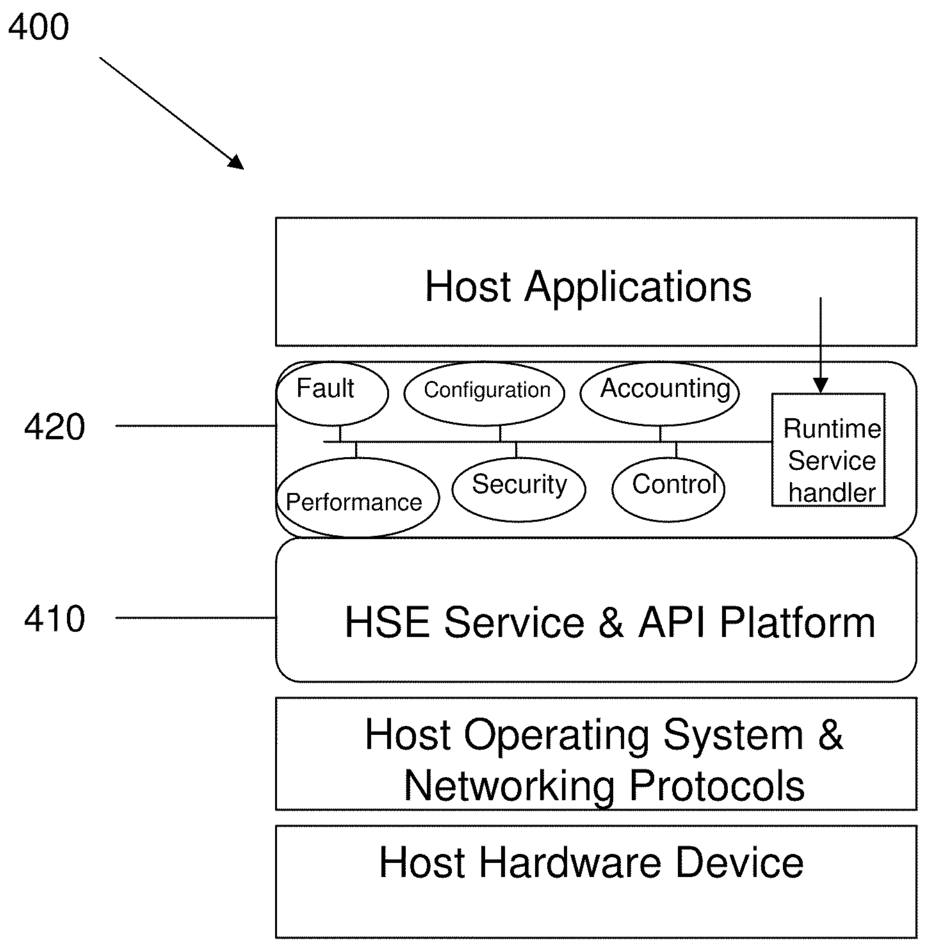
400
Host Applications
420
Fault
Configuration
Accounting
Runtime Service handler
Performance
Security
Control
410
HSE Service & API Platform
Host Operating System & Networking Protocols
Host Hardware Device

Figure 6

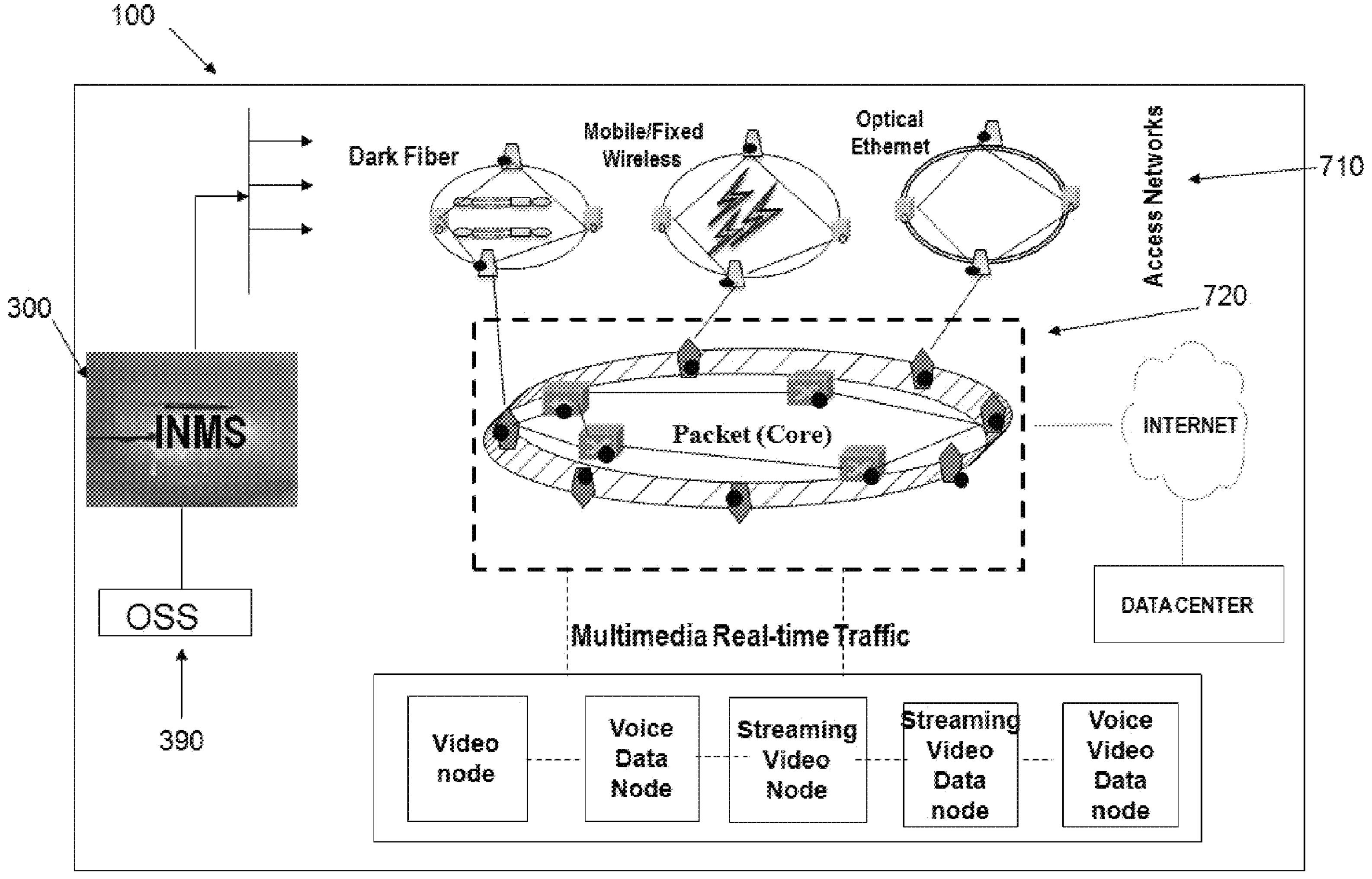
100
300
INMS
OSS
390
Dark Fiber
Mobile/Fixed
Wireless
Optical
Ethernet
Access Networks
710
720
Packet (Core)
INTERNET
DATA CENTER
Multimedia Real-time Traffic
Video
node
Voice
Data
Node
Streaming
Video
Node
Streaming
Video
Data
node
Voice
Video
Data
node

Figure 7

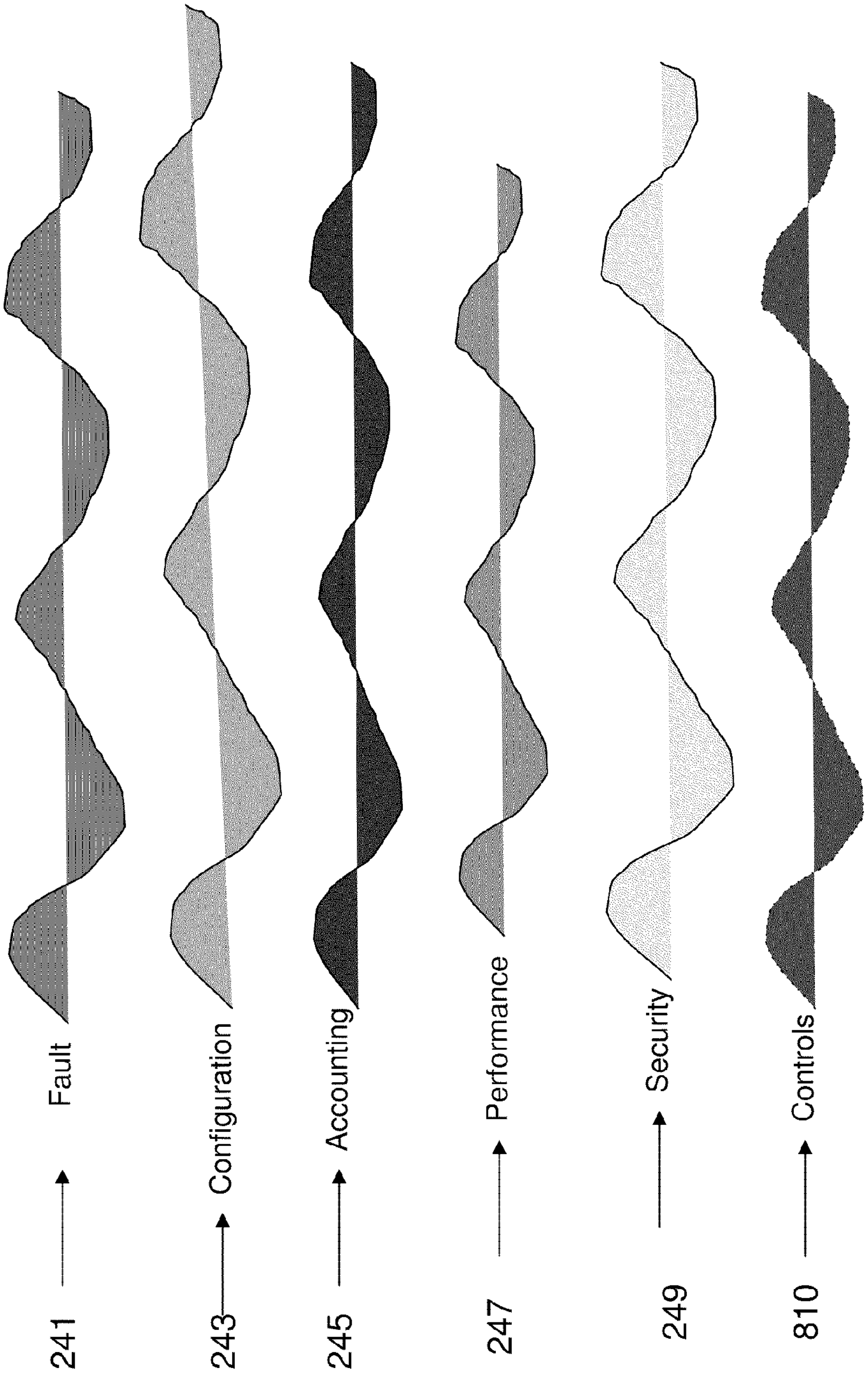
241
Fault
243
Configuration
245
Accounting
247
Performance
249
Security
810
Controls

Figure 8

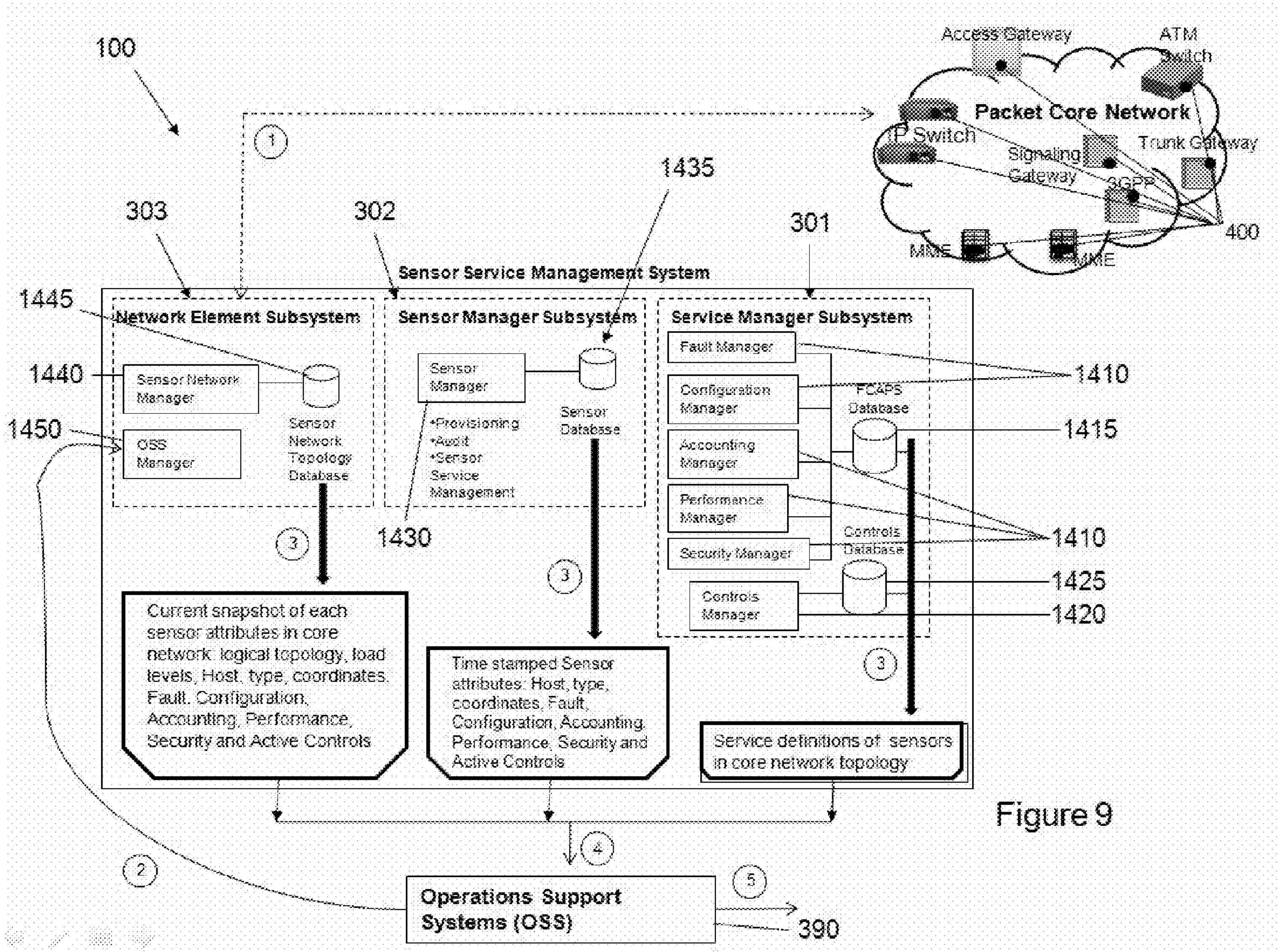
100
Access Gateway
ATM Switch
Packet Core Network
IP Switch
Signaling Gateway
Trunk Gateway
3GPP
MME
MME
400
1
1435
303
302
301
Sensor Service Management System
1445
Network Element Subsystem
Sensor Manager Subsystem
Service Manager Subsystem
1440
Sensor Network Manager
1450
OSS Manager
Sensor Network Topology Database
Sensor Manager
*Provisioning
*Audit
*Sensor Service Management
Sensor Database
Fault Manager
Configuration Manager
Accounting Manager
Performance Manager
Security Manager
Controls Manager
FCAPS Database
Controls Database
1410
1415
1410
1425
1420
1430
3
3
3
Current snapshot of each sensor attributes in core network: logical topology, load levels, Host, type, coordinates. Fault, Configuration, Accounting, Performance, Security and Active Controls
Time stamped Sensor attributes: Host, type, coordinates, Fault, Configuration, Accounting, Performance, Security and Active Controls
Service definitions of sensors in core network topology
2
4
5
Operations Support Systems (OSS)
390

Figure 9

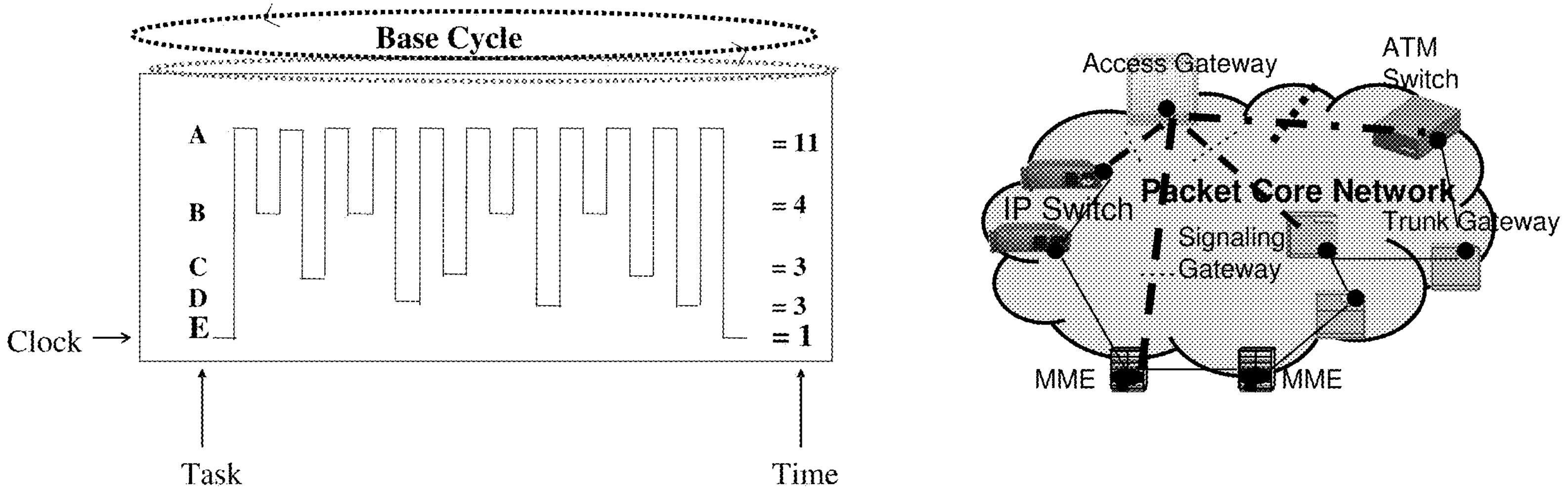
Base Cycle
Clock
A
B
C
D
E
= 11
= 4
= 3
= 3
= 1
Task
Time
Access Gateway
ATM
Switch
IP Switch
Packet Core Network
Signaling
Gateway
Trunk Gateway
MME
MME

Figure 10

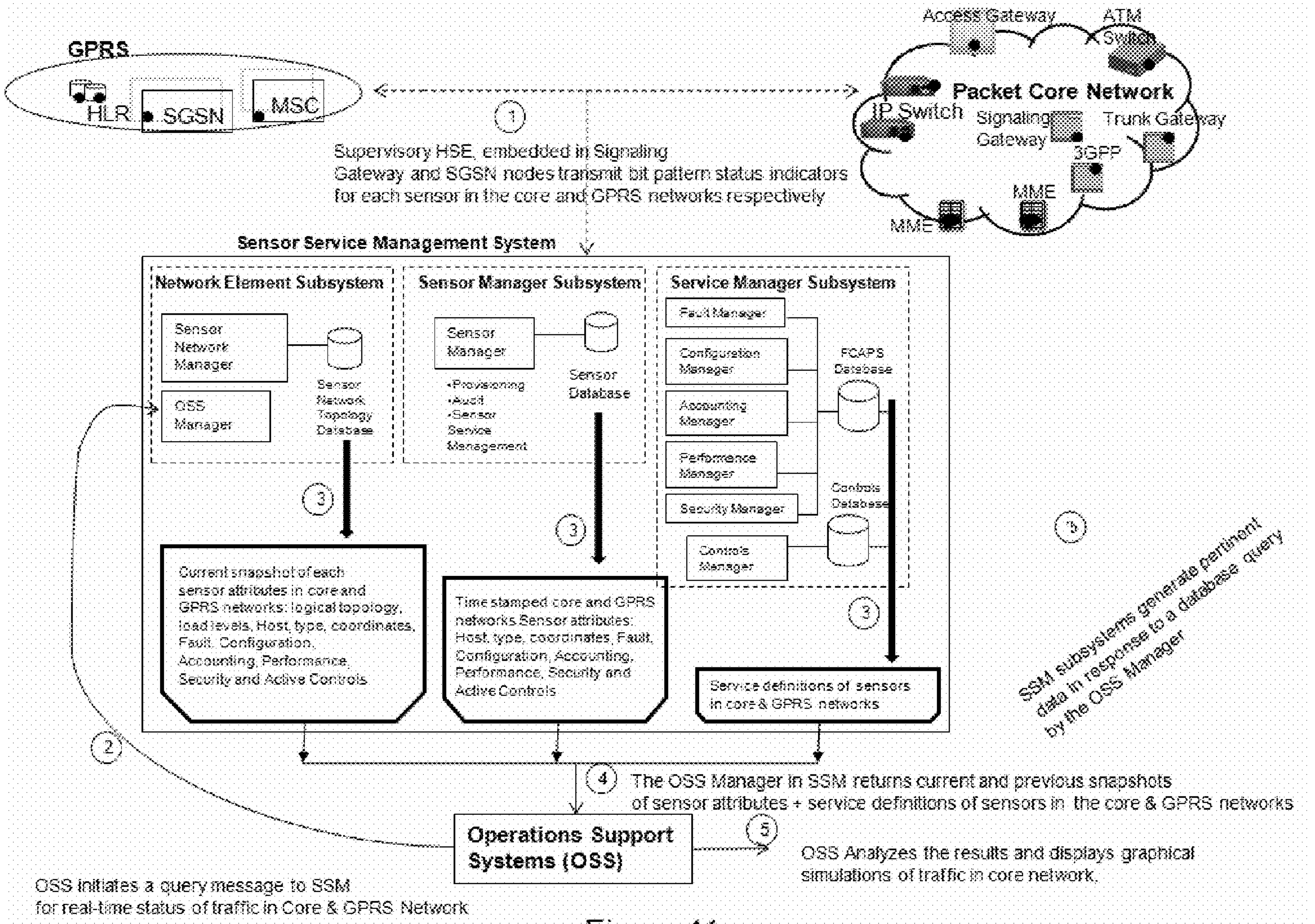
GPRS
HLR
SGSN
MSC
1
Supervisory HSE, embedded in Signaling
Gateway and SGSN nodes transmit bit pattern status indicators
for each sensor in the core and GPRS networks respectively
Access Gateway
ATM
Switch
Packet Core Network
IP Switch
Signaling
Gateway
Trunk Gateway
3GPP
MME
MME
Sensor Service Management System
Network Element Subsystem
Sensor
Network
Manager
OSS
Manager
Sensor
Network
Topology
Database
Sensor Manager Subsystem
Sensor
Manager
•Provisioning
•Audit
•Sensor
Service
Management
Sensor
Database
Service Manager Subsystem
Fault Manager
Configuration
Manager
Accounting
Manager
Performance
Manager
Security Manager
Controls
Manager
FCAPS
Database
Controls
Database
3
3
3
Current snapshot of each
sensor attributes in core and
GPRS networks: logical topology,
load levels, Host, type, coordinates,
Fault, Configuration,
Accounting, Performance,
Security and Active Controls
Time stamped core and GPRS
networks Sensor attributes:
Host, type, coordinates, Fault,
Configuration, Accounting,
Performance, Security and
Active Controls
Service definitions of sensors
in core & GPRS networks
5
SSM subsystems generate pertinent
data in response to a database query
by the OSS Manager
2
4
The OSS Manager in SSM returns current and previous snapshots
of sensor attributes + service definitions of sensors in the core & GPRS networks
Operations Support
Systems (OSS)
5
OSS Analyzes the results and displays graphical
simulations of traffic in core network.
OSS initiates a query message to SSM
for real-time status of traffic in Core & GPRS Network

Figure 11

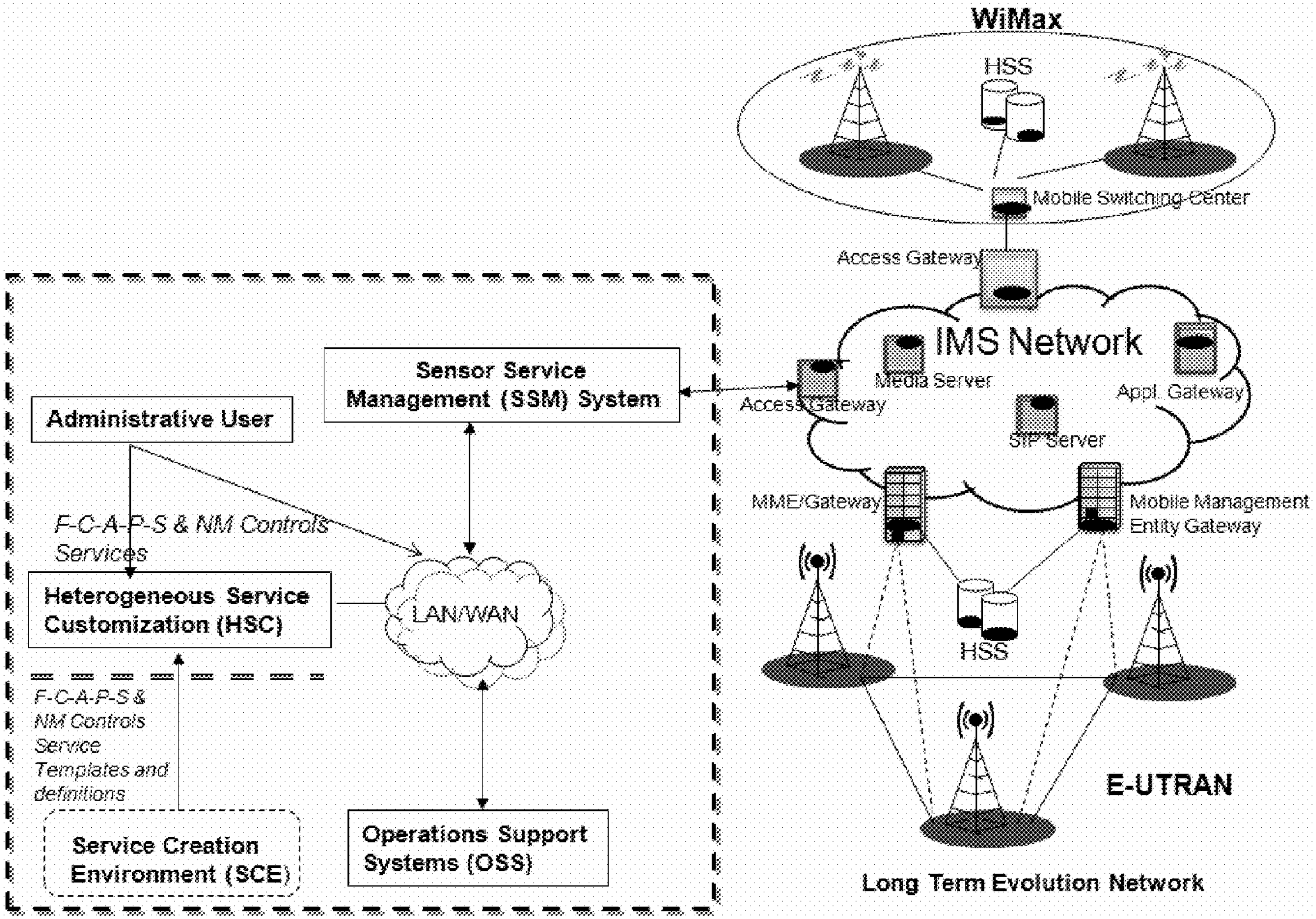
WiMax
HSS
Mobile Switching Center
Access Gateway
IMS Network
Media Server
Appl. Gateway
SIP Server
Access Gateway
MME/Gateway
Mobile Management
Entity Gateway
HSS
E-UTRAN
Long Term Evolution Network
Sensor Service
Management (SSM) System
Administrative User
F-C-A-P-S & NM Controls
Services
Heterogeneous Service
Customization (HSC)
LAN/WAN
F-C-A-P-S &
NM Controls
Service
Templates and
definitions
Service Creation
Environment (SCE)
Operations Support
Systems (OSS)

Figure 12

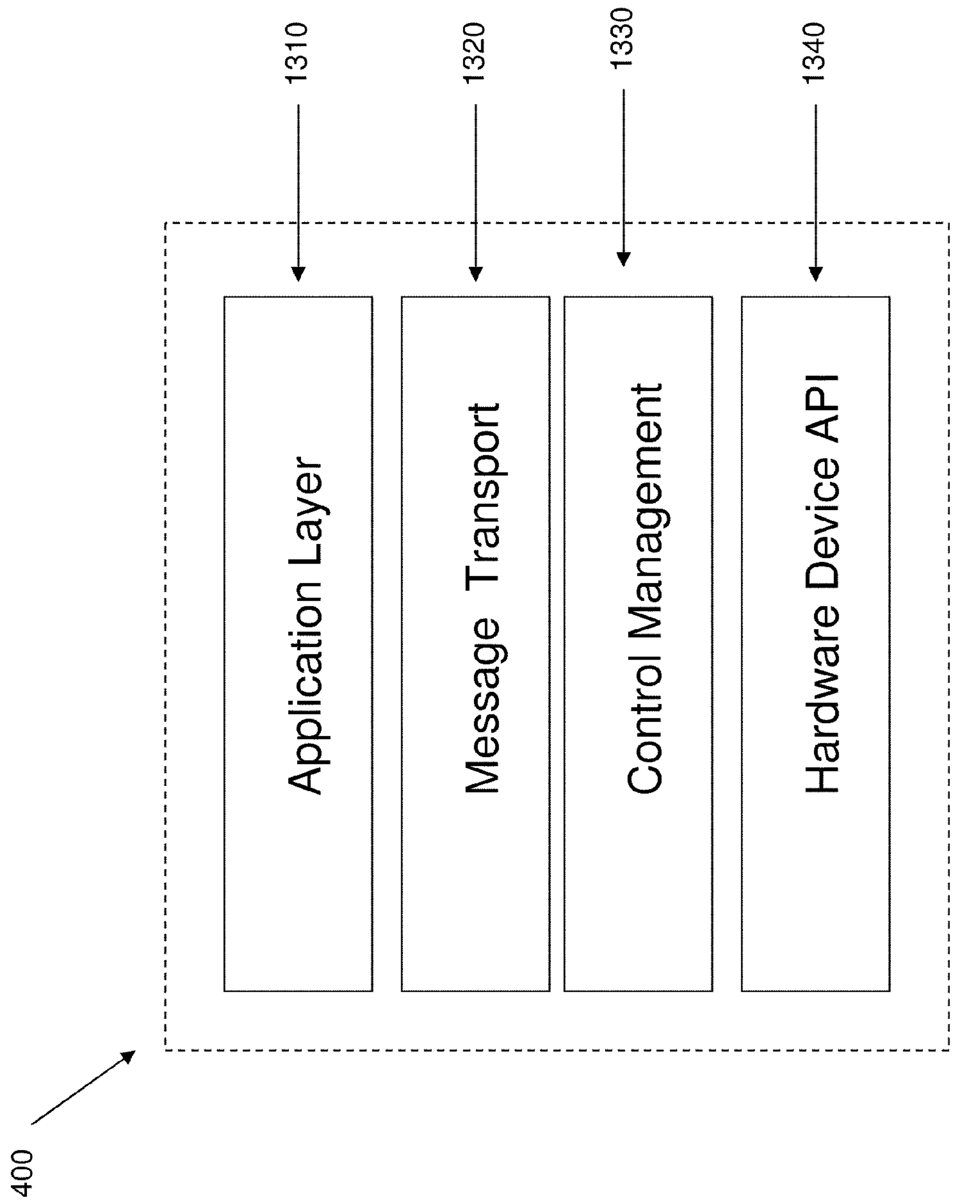
1310
1320
1330
1340
Application Layer
Message Transport
Control Management
Hardware Device API
400

Figure 13

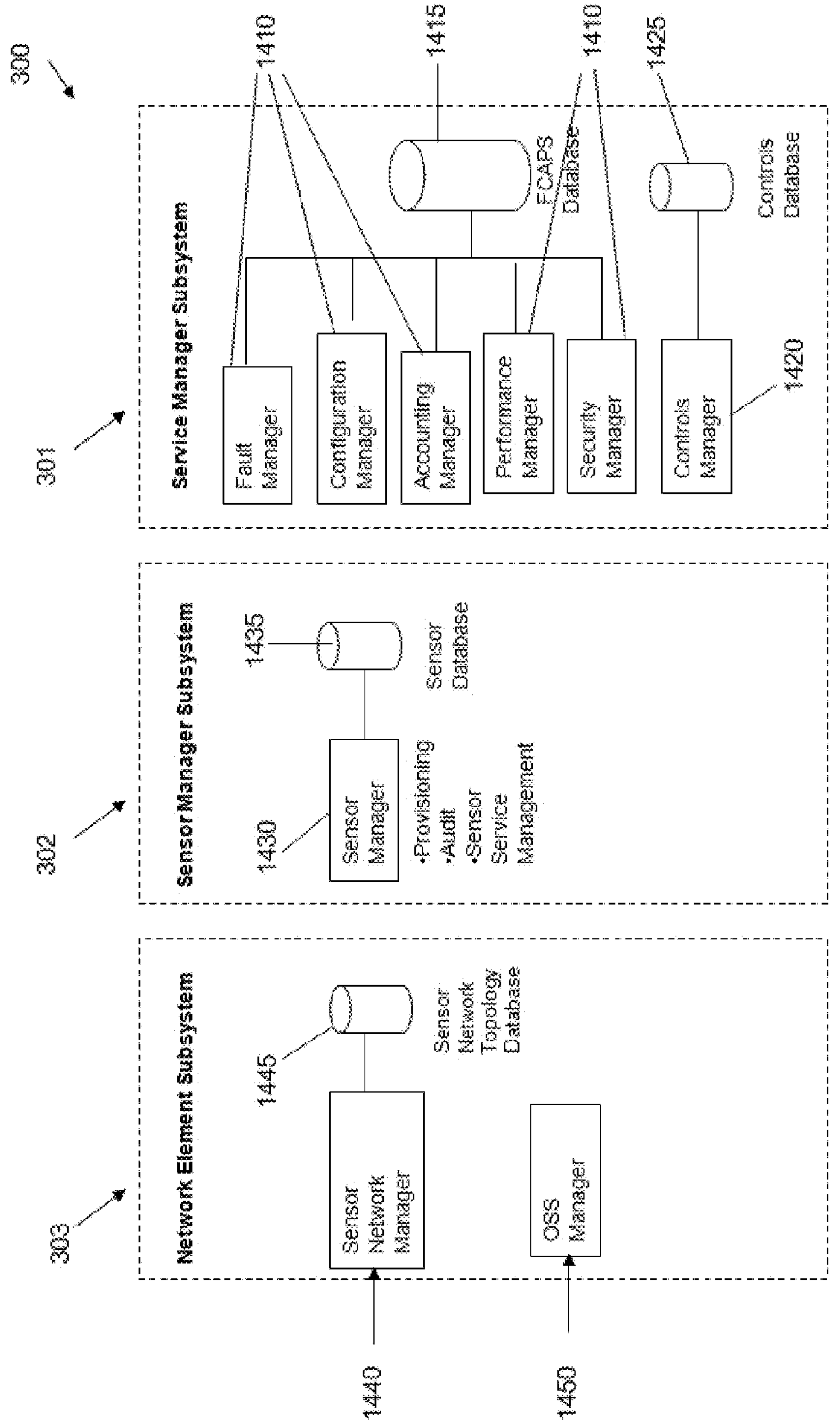
300
301
Service Manager Subsystem
Fault Manager
Configuration Manager
Accounting Manager
Performance Manager
Security Manager
Controls Manager
1410
1415
1410
1425
FCAPS Database
Controls Database
1420
302
Sensor Manager Subsystem
1435
Sensor Database
1430
Sensor Manager
•Provisioning
•Audit
•Sensor Service Management
303
Network Element Subsystem
1445
Sensor Network Topology Database
Sensor Network Manager
OSS Manager
1440
1450

Figure 14

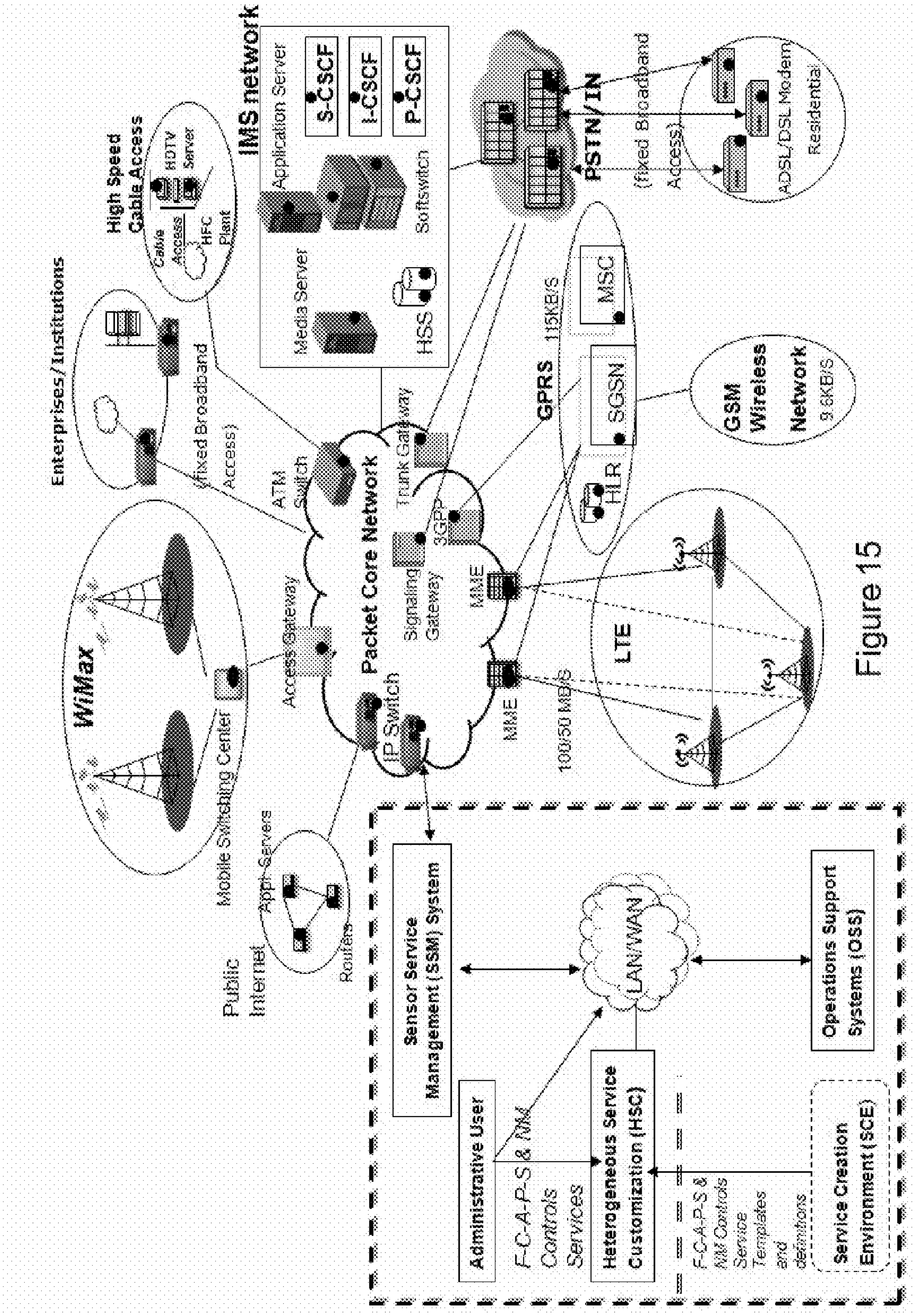
Enterprises/Institutions
(fixed Broadband Access)
High Speed Cable Access
Cable Access
HFC Plant
HDTV Server
IMS network
Application Server
S-CSCF
I-CSCF
P-CSCF
Media Server
Softswitch
HSS
PSTN/IN
(fixed Broadband Access)
ADSL/DSL Modem Residential
WiMax
Mobile Switching Center
Access Gateway
ATM Switch
Packet Core Network
Trunk Gateway
Signaling Gateway
3GPP
MME
MME
IP Switch
GPRS
115KB/S
MSC
SGSN
HLR
GSM Wireless Network
9.6KB/S
LTE
100/50 MB/S
Public Internet
App Servers
Routers
Sensor Service Management (SSM) System
LAN/WAN
Operations Support Systems (OSS)
Administrative User
F-C-A-P-S & NM Controls Services
Heterogeneous Service Customization (HSC)
F-C-A-P-S & NM Controls Service Templates and definitions
Service Creation Environment (SCE)

Figure 15

Table 1.0 Network Management Service Instance Interaction Descriptions

State	Description
Active	Service Instance is currently provisioned on a sensor
Cancel	A Service Instance has exceeded the length of retention period in either Failed or Conflict status, and could no longer be restored to Valid status
Conflict	The Service Instance contains reference to at least one attribute that is no longer installed in the *SSM system Sensor database* or the *SSM Network Manager database*
Failed	SSM is unable to activate a Service Instance in Pending status.
In-valid	The Service Domain file fails validation during the HSC service customization process. The file may be corrupt, contain invalid Service Definition attributes, formats and/or values
Pending	Service Instance is pending activation
Valid	The Service Domain file passes all validations during the HSC service customization process, and is ready to be installed on the SSM system

Service Instance Status Interaction Descriptions			
	Service Interaction		
Label	**Name**	**Type**	**Description**
1	Create to Valid	HSC Internal	HSC validates Service Domain template, verifies the service customization and determines service is accurate
2	Create to In-valid	HSC Internal	HSC validates Service Domain template, verifies the service customization and determines service is inaccurate
3	Valid to Pending	i. HSC system Administrator ii. SSM system Internal	i. The HSC administrator initiates request to re-activate a Valid Service instance ii. SSM system changes the Service Instance status from Valid to a transient state: Pending
4	Active to Valid	SSM system Internal	In order to modify an existing active service instance, the SSM system retires the active service instance by changing its status from Active to Valid. The old service is replaced by the newly acquire service from the HSC.
5	Pending to Active	SSM system Internal	SSM sets the Service Instance status from Pending to Active using one of the criteria: i. After successfully retiring the Service Instance from Active to a Valid state ii. No Service Instance exists in Active state
6	Pending to Failed	SSM system Internal	SSM system sets the Service Instance status from Pending to Failed after an unsuccessful attempt to retire the Active Service Instance
7	Failed to Valid	SSM system GUI	End user initiates request to modify/restore a failed Service Instance. The SSM system initially verifies the modified Service exists before changing the status from Failed to Valid
8	Valid to Conflict	SSM system Internal	The SSM system detects one or more inconsistent Service Definition attributes associated with a Valid Service Domain. The following is a scenario for the latter: *Every Service Domain contains a reference to a set of attributes -Sensor type, protocol and other unique host sensor attributes, which are installed in the SSM system Sensor database. If, however, one of these attributes is deleted from the database, but referenced in a Service Definition for a Valid Service Domain, then the Service Definition will be inconsistent, and its Service Domain/Instance will automatically transition to a status of "Conflict"*
9	Conflict to Valid	HSC system Service Modification GUI	The HSC end user initiates request to correct all inconsistent Service Definitions then submits the revised Service Domain for validation. HSC internal validates the modified Service Domain prior to changing the status to Valid
10	Failed to Cancel	SSM system GUI	The SSM system end user initiates a request to retire a Failed Service Instance
11	Conflict to Cancel	SSM system GUI	The SSM system end user initiates a request to retire Service Instance in Conflict status

Figure 16

Bit Vector Analysis

Alarm Levels/Query

Bit Position:	1	2		Descriptions
	0	0	Pre-emptive	Host is stable but may not be in optimal state
	0	1	Minor	Minor degradation detected in host
	1	0	Major	Major degradation detected in host
	1	1	Query	Request status of receiver node

Network Management Types & Control

Bit Position:	3	4	5		Descriptions
	0	0	1	Fault	Fault Management
	0	1	0	Configuration	Configuration Management
	1	0	0	Accounting	Accounting Management
	0	1	1	Performance	Performance Management
	1	0	1	Security	Security Management
	1	1	0	**Control**	**Control Activation/Removal**

HSE Components (1 through "n-5")

Bit Position:	6	7	8		n
Software/Hardware Components/Facility	0	1	1	0	0

Figure 17

Example 1: Pre-emptive Optimal Diagnosis

0	0	0	0	0	0	0	0	0	0

Example 2: Stable but less optimal Diagnosis:

0	0	0	1	1	0	0	1	0	0

Example 3: Minor Configuration Alarm Diagnosis:

0	1	0	1	0	0	0	0	1	0

Example 4: Minor Configuration Alarm Diagnosis:

1	1	1	0	1	0	0	0	0	0

Example 5: Optimal Security Response:

0	0	1	0	1	0	0	0	0	0

Example 6: Stable, but less optimal Security Response:

0	0	1	0	1	0	1	0	0	0

Example 7: Minor Security Alarm Response:

0	1	1	0	1	1	0	0	0	0

Figure 18

APPARATUS AND METHODS FOR REAL-TIME MULTIMEDIA NETWORK TRAFFIC MANAGEMENT AND CONTROL IN WIRELESS NETWORKS

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application claims the benefit of U.S. Provisional Patent Application No. 61/186,655, filed Jun. 12, 2009, the disclosure of which is expressly incorporated by reference herein.

FIELD OF THE INVENTION

The present invention relates to network management procedures, and particularly to a real-time network management and control system for multimedia streaming traffic in telecommunications networks, such as 4G wireless networks.

BACKGROUND OF THE INVENTION

Current network management procedures are concerned primarily with monitoring aspects, which do not provide real-time control capabilities. Network management involves a set of activities and techniques that are required to plan, design, control, maintain and grow a network infrastructure and its associated services. These activities include monitoring the network and the ability to take prompt action to efficiently maintain the service-level objectives and to control the flow of traffic when necessary. The OSI reference model classifies network management functions into five functional areas: fault management, configuration management, accounting management, performance management, and security management. These functions are collectively referred to as "FCAPS". Network management activities also include detection, identification, investigation and resolution of faulty network elements and transmission facilities. In the 3G wireless networks and prior telecommunications environment, network monitoring is accomplished by logically connecting the network elements to remote Element Management Systems, which are under the control of one or more Network Management Systems (NMS). The NMS is collocated with various Operations Support Systems in a Network Operations Center (NOC). Effective network management depends on the coordination of controls across the various Element Management Systems. These controls may include schedule changes, provisioning, fault and configuration management modifications. In today's environment, control coordinations are handled by NOC engineers/operators through manual procedures, which present a number of setbacks for the complex and heterogeneous real-time multimedia traffic in 4G wireless networks. The Simple Network Management Protocol (SNMP) framework is the dominant industry standard. The SNMP framework consists of three key elements: The standard Management Information Base (MIB), The Structure of Management Information (SMI), and The Simple Network Management Protocol (SNMP). Despite its popularity, the SNMP framework has a number of disadvantages. The SNMP framework assumes a static managed object. Every data item must be carefully pre-defined, including its type, size and access restrictions before it can be used in the MIB.

With the complexity of real-time multimedia traffic streams across different bandwidths of wireless and wired networks, it would require tremendous time, effort and patience to accurately pre-define the wide variety of managed objects for real-time multimedia traffic in the wireless and wired networks, such as 4G networks. Moreover, modeling the characteristics of real-time multimedia traffic as static objects may lead to inaccurate representations. To retrieve SNMP data items (i.e., discrete values), the manager must periodically obtain/poll all the discrete values associated with the object(s); the manager stores the values, and determines whether the retrieved values are of interest then constructs complimentary information, which identifies implementation of appropriate network management functions. The lack of direct filtering mechanism makes real-time network management process cumbersome. The periodic polling of SNMP discrete values for multimedia traffic over a WAN connection consumes a lot of bandwidth, which may contribute to network traffic congestion due to the large volumes of diverse data items (i.e., attributes) associated with real-time multimedia traffic managed objects. The length of the pooling period, accompanied by the data analysis of the discrete values and subsequent information construction phases introduce latency, which is undesirable for real-time video communications.

Second-generation (2G and 2.5G) wireless systems, such as CDMA, GSM and IS-95 were designed primarily to transport speech and low-bit rate data in non real-time. A service provider's 2G or 2.5G wireless network is primarily homogeneous, and therefore easily managed by employing standards defined by the International Telecommunications Union for network management, such as Common Management Information Protocol (CMIP), Telecommunications Management Network (TMN) protocol.

The Third-generation (3-G) wireless networks support higher bit rate data, along with convergence of speech and data traffic. The 3-G systems including CDMA2000, UMTS, GPRS and WiMax were developed independently to target different service types and high bit-rate data services. The 3-G network management paradigm procedure is non-integrated. The International Mobile Telecommunications-2000 (IMT-2000) provides a family of standards for the telecommunications services. However, the SNMP is widely used for data services.

The Fourth-generation (4-G) wireless network paradigm, on the other hand, is designed to provide higher-bit rates for real-time video, voice and data traffic, which may traverse multiple wireless network technologies with different quality of network element technologies (reliability—Fault, Configuration), billing methods (Accounting), quality of service (QoS) levels (Performance) and Security policies. Hence A 4-G mobile user may concurrently connect to different QoS wireless networks with the expectations of higher-bit rates for real-time video, voice and data streams. Effective real-time network management methodology is therefore necessary in order to maintain higher-bit rates for real-time traffic. More particularly, it would be desirable that in the 4G wireless networks:

Equipment failures should be minimized and the potential impact of Faulty equipment resolved in real-time

The design of universal end-user terminals (and wireless network elements) to operate in different wireless networks imposes a new level of complexity (e.g., size, power consumption, operating systems) for a 4-G device Configuration. Configuration failures should therefore be resolved in real-time

Multiple operators may have different billing/Accounting systems. A mobile 4-G end-user's accounting information may be collected and managed from multiple wireless service providers. The end-user Accounting information should be collected seamlessly from the

- originating, transit and terminating nodes in various networks in real-time in order to provide detailed and accurate billing information to the 4-G mobile end-user
- Degradation of end-to-end QoS for multimedia services that span multiple networks, IP and non-IP based systems should be detected and corrected in order to provide acceptable Performance levels in real-time
- Different wireless networks may have varying levels of security. Hence to maintain uniform security across the originating, transit and terminating networks, it would be desirable to provide real-time Security across the impacted networks

Today's network management procedures are reactive. To effectively manage real-time multimedia traffic in wireless networks, namely 4G wireless networks, there needs to be a paradigm shift from a reactive approach to a distributed, fully integrated, pre-emptive real-time network management and real-time control framework.

SUMMARY OF THE INVENTION

It is, therefore, an object of the invention to provide a network management system which can overcome the above problems. A novel network management procedure to facilitate real-time network management and real-time control capabilities of multimedia traffic in wireless networks, more particularly 4G wireless networks is proposed. The methodology provides pre-emptive network management and control capabilities. The methodology is based on the shared intelligence of distributed Heterogeneous Sensor Entities (HSE) and a Sensor Service Management (SSM) system. The HSEs are distributed real-time embedded systems provisioned in various network elements (nodes). The HSE performs fault, configuration, accounting, performance and security network management functions in real-time; and real-time network management control activations and removals in both wireless and wired network elements. The SSM system facilitates automated decision making, rapid deployment of Heterogeneous Sensor Entities and real-time provisioning of network management and control services. The service communication framework amongst various HSEs and the SSM is provided by the Heterogeneous Service Creation (HSC) system. The HSC creates the heterogeneous service elements for Fault, Configuration, Accounting, Performance and Security network management functions, and network management controls. The HSC, SSM and HSE framework provides an integrated view of real-time network management and control capabilities for wired and wireless networks, such as 4G wireless networks, and clusters of disparate (independent) networks. The independent networks include standalone wired voice networks, like Legacy, cellular networks, data networks, and/or cable networks, belonging to another domestic or international service provider, which provide a transit route for real-time multimedia streams originating from or terminating at a 4G wireless network for example. When a service provider utilizes clusters of physically independent networks to provide real-time multimedia services to its end-users, the voice, video and data traffic could be individually transported over a converged network, consisting of Public Switched Telephone Networks, cable networks, data networks and other possible networks. This invention provides real-time network management and control capabilities of multimedia traffic for both wireless networks and converged networks.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1**(*a*) is a schematic illustration of a centralized network management (prior art);

FIG. **1**(*b*) is a schematic illustration of network management functions (prior art);

FIG. **2** is a schematic illustration of FCAPS Service Version Management;

FIG. **3** is a schematic illustration of for real-time Multimedia Traffic Network Management System framework;

FIG. **4** is a schematic illustration of network management service creation model;

FIG. **5** is a schematic illustration of an integrated network management architecture;

FIG. **6** is a schematic illustration of a heterogeneous sensor entity;

FIG. **7** is a schematic illustration of a context diagram for an integrated network management framework logical partitioning of a network infrastructure;

FIG. **8** illustrates real-time network management functions and control capabilities as continuous streams of service elements;

FIG. **9** is a schematic illustration of a real-time network management and control of a cluster;

FIG. **10** is a schematic illustration of an embedded heterogeneous sensor entity automatically senses congestion within its node;

FIG. **11** is schematic illustration of analysis of real-time multimedia network traffic management and control operations;

FIG. **12** is a schematic illustration of real-time Multimedia Network Traffic Management system framework for 4G wireless broadband networks as an example;

FIG. **13** is a schematic illustration of a second embodiment of a heterogeneous sensor entity;

FIG. **14** is a schematic illustration of Sensor Service Management System;

FIG. **15** is a schematic illustration of real-time Multimedia Network Traffic Management system framework for 4G wireless networks and converged heterogeneous networks as examples;

FIG. **16** is a table of terms and definitions for the different states and state transitions for FCAPS service instances; and

FIG. **17** is an illustration of various fields for a Bit Vector Analysis in accordance with an embodiment of the present invention.

FIG. **18** illustrates diagnosis examples of the Bit Vectors of FIG. **17**.

DETAILED DESCRIPTION OF THE INVENTION

Various features of selected embodiments of this invention will now be described with reference to the figures. The spirit and scope of the invention is not limited to the embodiments selected for illustration. Furthermore, the system may vary as to configuration and details of the parts, and that the method may vary as to the specific steps and sequence, without departing from the concepts as disclosed herein.

In order to clarify certain aspects of the embodiments disclosed hereafter, various terms used herein are defined.

An edge router—is a device that routes packets between a logical network and the core routers.

Core router—is a device that may route packets to an edge router and nodes within a network, the core router typically resides within the middle or backbone of the LAN.

Access router—A device used to connect remote sites. This router is required at both ends of the remote sites and provides the protocol conversion between the LANs over the WAN.

Active State—See FIG. **16** Table 1.0

Cancel State—See FIG. **16** Table 1.0

Conflict State—See FIG. **16** Table 1.0
Failed State—See FIG. **16** Table 1.0
In-valid State—See FIG. **16** Table 1.0
Pending State—See FIG. **16** Table 1.0
Valid State—See FIG. **16** Table 1.0

The present invention relates to the aspects of network management system, such as real time network management, which may be applied in a range of networks, simple or complex. A basic element of a network typically includes hardware, software, and protocols. The interrelationship of these elements constitutes a network infrastructure. The network infrastructure is the topology in which nodes, any device connected to a network (e.g., computer, personal digital assistants (PDAs), cell phones, printer, or any device with an internet protocol address), of a local area network (LAN), a metropolitan area network (MAN), wide area network (WAN) or an international gateway network as examples, are connected to each other. These connections involve network elements (i.e. routers such as edge, core and access routers, switches, bridges, PDAs, servers, modems and hubs) using cables (i.e. copper or fiber) or wireless technologies. If a network is thought of as a means of transport, the network protocols are the "traffic rules". The network protocols define how devices in the network communicate. For example, network protocols include such specifications as the methods that can be used to control congestion in the network and how application programs will communicate and exchange data. Key areas in network management include network operations, security, and problem determination. Because businesses depend heavily on the availability of data processing systems, problems in the network must be addressed quickly. Some symptoms of a network that need to be addressed immediately might include error messages, unusual network traffic, load balancing, service degradation, slow response time, no system response or low throughput. One embodiment of the present invention relates the decreasing the response time for addressing these problems. The embodiment hereafter details how a real-time multimedia network traffic management and control system functions.

1. Real-Time Network Management and Control Infrastructure

With reference to FIG. **3**, one embodiment of a system and apparatus for multimedia network traffic management and control according to an example of the invention (herein referred to as the "Model") **100** may comprise a Heterogeneous Service Customization system (HSC) **200**, a Sensor Service Management System (SSM) **300**, and a Heterogeneous Sensor Entity (HSE) **400**. As used herein the term heterogeneous refers to comprising dissimilar elements or parts (e.g., a heterogeneous network, may comprise of routers including edge, core and access routers for example, computers with different operating systems, additional devices like cell phones, printers, or PDAs, all being interconnected within the same network). The Model **100** provides latency-free communication, and seamless reliable delivery of heterogeneous multimedia services amongst a wide variety of multi-access end user technologies and distributed services. In a functioning environment, the Model **100** may have a user who may access the SSM **300** via a graphical user interface (GUI). The GUI may communicate with the SSM **300** using a metropolitan area network (MAN), local area network (LAN), a wide area network (WAN), or by any other means known to a person having ordinary skill in the art. Direct access to the SSM **300** is also possible, however accessing the SSM **300** via the MAN, LAN, WAN, or the like, improves performance of the Model **100**. Additionally, the user may have direct access to the HSC **200**, or access may be established using a MAN, LAN, WAN, or by any current or future technology and other means known to a person having ordinary skill in the art.

Additionally, the Model **100** may comprise a Service Creation Environment (SCE) **210**. The SCE **210** may provide the Model **100** with services ready for deployment or customization. If a service provided by the SCE **210** requires customization, the service may be communicated to the HSC **200** for customization. Communication between the SCE may be direct, or via a MAN, LAN, WAN, or any other means known to a person having ordinary skill in the art. As illustrated in FIG. **3**, the SSM **300** communicates with a packet core network, working with the HSE **400** in real-time. Each network in the packet core is independent from one another. For example, one packet core network may include a fixed broadband network, 3G and cellular wireless networks employing internet protocol multimedia system (IMS), as well as a broadband wireless 4G networks. In this example, each individual network includes at least one HSE **400** in its nodes. Each node communicates with the packet core network node, which may be managed by the SSM **300**. The SSM **300** may also communicate with a variety of core networks. These networks may include Internet Protocol (IP) core networks, Dense Wavelength Division Multiplexing network, or any other network known to a person having ordinary skill in the art. However, for illustrative purposes a Packet Core network is provided in FIG. **3**. With reference to FIG. **7**, the Model **100** provides latency-free communication, and seamless reliable delivery of heterogeneous multimedia services by logically portioning networks into an Access Network Domain **710** that may facilitate multi-technology, multi-access and higher-speed bandwidth, and a Core Network Domain **720** that may facilitate convergence of higher throughput data and voice networking, multi-access network technologies, and heterogeneous protocols and services. As illustrated in FIG. **8**, the HSC **210** creates a set of Heterogeneous real-time Network Management Service Applications for Fault **241**, Configuration **243**, Accounting **245**, Performance **247**, and Security **249** (collectively referred to as "FCAPS") and Network Management Control **810**. For example, a security specialist uses the HSC to create a set of parameters for the Security **249** application for use in the Model **100**. The HSC **200** transforms the FCAPS service elements templates based on the managed device's type and surroundings. Managed devices may be any device (i.e. nodes, network elements, etc.) used within the model **100**. The HSC validates and builds the service executables. The service elements are installed on the SSM **300**, where the SSM **300** manages the state of each service element. The waves illustrated in FIG. **8** are service waves which are not required to be uniform with one another. Additionally, the service waves demonstrate a continuous stream of network management, which is a departure from the traditional discrete network management procedure. For purposes of this figure, the wavelengths appear in similar size and frequency to show a system that is continuous and streaming in real-time.

For example, an HSE **400** used to emulate network security may use a service element template customized to emulate internet traffic and control for the device that HSE **400** is emulating. The SSM **300** may communicate with the HSE **400** using two mediums, the Access **710** and Core **720** Networks as the primary transport medium, and an Heterogeneous Sensor Network (HSN) as the secondary transport medium. The HSN is a packet network, designed to carry bit-mapped Vectors of network management information amongst HSE(s) **400**, and SSM **300**. Bit-mapped Vectors may be a bit sequence having Boolean values. Preferably, multimedia traffic is carried over the Access **710** and Core **720** Networks. HSN bit-mapped vectors may be carried over the Access **710** and Core **720** Networks depending on the multimedia traffic load-levels. Communication within the Model **100** may be established using wired technologies (i.e. copper, fiber, etc. . . .) or wireless technologies (i.e. LTE, WiMax, wi-fi, GSM, CDMA, etc. . . .) or any other means known to a person of ordinary skill in the art. The Model's **100** functionality is independent of the type of network connectivity.

With reference to FIG. **2**, a description of the deployment of the FCAPS and Control services deploy in the Model **100**, and the states in which they exist in every sense of time is described. For illustrative purposes, the Fault Management System is used to show the deployment and states in which each service exists. Any of the FCAPS and Control management systems may be used within this description. For example, with reference to FIG. **3**, when a user creates a service in the SCE **210**, this service is sent to the HSC **200**, which then validates the service. If valid, the HSC **200** assigns a state of valid. If invalid, the HSC **200** returns the service to the SCE **210**. If valid, the HSC **200** will send the service to the SSM **300** (see FIG. **3**), where the service resides and awaits deployment. The service resides in the FCAPS database **1415** (see FIG. **14**), which serves as a repository. When you have a service that is valid, it resides in the SSM **300**. From here the service goes to a pending state. Here a user may change the service or provision the service. To provision the service, the user may initiate a request to activate or reactivate a valid service instance. Here the service goes from valid to pending. The SSM **300** changes the status of the service. The change from a pending state to an active state is made based on one of the descriptions listed in FIG. **16**. (See Table 1.0 for the list of Service Instance Status Interaction Descriptions.) Furthermore, with a Fault management service, the SSM **300** puts the valid state into an active state, and then looks to the sensor to see if a state already exists on the sensor. The SSM **300** will first try to retire the old state on the sensor, then bring the new state to valid and replace the retired state. Once the state is retired, the sensor may be absent a state, until the new state is provisioned.

2. Heterogeneous Service Customization (HSC) System

One function of Heterogeneous Service Customization (HSC) System **200** is to create a set of heterogeneous Network Management Service Applications for FCAPS and Traffic Control. With reference to FIG. **4**, the HSC **200** architecture may be comprised of four layers, a Network Management Control Layer **220**, a Network Management Function Layer **240**, a Behavior Layer **260**, and an Attribute Layer **280**. The Network Management Control Layer **220** may provide extensions to the Open System Interconnection (OSI) network management reference model. The Network Management Control Layer **220** layer may specify the procedures for activating and removing network management controls used by the HSE **400**. The Network Management Control **220** allows the HSE **400** to alter the flow of traffic in the network in support of the network management's objectives. The Network Management Controls **220** may be mapped to individual states defined by a State Machine (SM), which defines and emulates the transition of pertinent operations for a given Network Element. Programmable Decision Graphs may be employed to activate and remove Network Management Controls **220**. Decision Graph is defined as a template of defined parameters.

The Network Management Function Layer **240** may be comprised of five distinct entities representing Fault Management **241**, Configuration Management **243**, Accounting Management **245**, Performance Management **247**, and Security Management **249**. Each continuous and streaming service entity may be defined based on a set of discrete states representing a set of conditions, and a set of events of the managed network element. Programmable decision graphs may be used to control the execution of the network management function **240** for each device.

The Behavior Layer **260** may represent the operations of the managed Network Element as a set of State Machines. This layer **260** provides a software abstraction of the network element's behavior. The Attribute Layer **280** may describe the characteristics of an HSE **400** and the managed node. For example, the Attribute Layer **280** may describe some characteristics such as the HSE **400** network domain ID, or Supervisory and Control parameters.

3. Sensor Service Management (SSM) System

One function of Sensor Service Management (SSM) System **300** may be to create heterogeneous service elements by customizing the HSC **200** service element templates, based on monitoring and control requirements of the HSE **400**. These requirements are derived from the HSE's **400** managed device types, device functions and its local surroundings. Additionally, the SSM **300** may partition the Access **710** and Core **720** networks into logical network clusters, which are groups of linked nodes, working together closely for improving performance and/or availability over what would be provided by a single node. Each cluster may be characterized by a graph representing a set of nodes, network elements and other managed device types. Also, the SSM **300** provisions executable code versions (service codes) of the service element templates to the appropriate HSE **400** applications in real-time. Executable codes are typically instructions for a node, in a form the node can directly use (i.e. execute). Communication between the SSM **300** and the HSE **400** is established using bit-mapped vectors for example. The provisioning dynamically incorporates the service codes into the HSE **400** applications. The SSM **300** may also receive audit or query requests from at least one Operation Support Systems (OSS) **390** to audit or query the status of remote managed nodes through the HSE **400**. Communication within the Model **100**, between the SSM **300** and the HSE **400** is in real-time. A second function of the SSM **300** may be to serve as a repository. For example, when you have a service in a Valid state, it resides in the SSM **300**. From this point, the Valid state goes to a Pending state. At this point a user may change the service or provision the Pending state service. To provision, the user may initiate a request to activate or reactivate a Valid state's service instance. The SSM **300** may then change the status. At this point the state goes from Valid to Pending. Later the state is changed from Pending to Active based on one of the possible criteria given in FIG. **16** Table 1.0. An example of a change in states for fault management services is set forth. The SSM **300** puts the valid state into an active state, then looks to the sensor to see if a service already exists on a sensor. The SSM **300** will first try to retire the old state on the sensor by sending a message to the sensor. The SSM **300** will then try to bring the new state to valid and replace the retired state on the sensor. At the point where the state is successfully retired by the SSM **300**, the sensor may have no states until the new state is provisioned by the SSM **300**. If the SSM **300** fails to retire the active state, the SSM **300** will move the new state status from Pending to Fail. When the service is in a Fail state, a user may initiate a request to modify or restore a service state. A state may Fail for a number of reasons, for example, if a node is down, or if the network is down. Once a verification of the node, network or other reason causing the Fail state is restored, the SSM **300** will begin the process again from Valid to Pending, and moves forward until the state is Active.

In an example of the invention, there is provided a system and method operable in conjunction with real-time management of Fault, Configuration, Accounting, Performance, Security and Control for updating information items in elements of wireless and converged network nodes and in the Sensor Service Management System. An example method comprises the steps of: (a) a sensor service management system defining and maintaining a master or golden copy of the network configurations, sensor attributes and network elements; (b) the sensors determining which information items of said network elements are of a type which must change in real-time based on a pre-emptive diagnostics of network elements and network clusters; (c) the sensor systems generating instructions to the Service Management System and other sensors using bit mapped vectors to represent real-time status of network elements, network management types (FCAPS) and Control; and non-optimal components of network elements; (d) responsive to the instructions from a sensor, the recipient sensor performs real-time analysis and determines corrective actions to maintain optimal network operations and network services; (e) responsive to the instructions from the sensor system, the sensor service management system updates the master or golden copy of the network topology and network element attributes; and the sensor service management instructs operation support systems about the real-time status of the network and components of the network elements. The method may further comprise the step of: the sensor systems performing real-time control of heterogeneous streams of Fault, Configuration, Performance, Accounting, Security and Control services in wireless and converged network element nodes. Additionally, the method may further comprise the step of: the sensor service management system performing real-time provisioning of heterogeneous streams of Fault, Configuration, Performance, Accounting, Security and Control services in wireless and converged network element nodes. Yet further, the method may further comprise the step of: the service creation system and the sensor service management system performing service version management for Fault, Configuration, Performance, Accounting, Security and Control service instances.

With reference to FIG. **5**, one embodiment of the SSM **300** architecture may comprise four components, a Network Management Service Creation Interface (NM-SCI) **320**, a Visual Interface **340**, a Host **360**, and a Network Element and Operation Support Systems Interface **380**. The NM-SCI **320** allows the FCAPS service and control templates to be installed on the SSM **300**. The Visual Interface **340** provides support for administrative and service customization. For example, types of Visual Interfaces **340** may be a web browser, graphical user interface (GUI), or any other interface known to a person having ordinary skill in the art. The interface **340** may be used by a security specialist to customize the security traffic control service elements to the requirements of the HSE **400**. Types of service customizations may include validation, verification, editing of decision graphs, specifications of attributes, exceptions, threshold values, administrative policies, and constraints. The service customizations may be stored on the SSM **300** and provisioned to an HSE **400**.

The Host **360** may comprise of subsystems including an HSE/CHSE Network Topology **361**, HSE/CHSE Network Management Controls **363**, and FCAPS Service Elements **365**. The HSE/CHSE Network Topology Subsystem **361** may partition the Access **710** and Core **720** network topology into logical clusters, and creates graph representations of each cluster. Each cluster comprises an HSE **400**. Each graph representation may be represented by a set of nodes within the cluster. The HSE/CHSE Network Topology Subsystem **361** may maintain a copy of the logical network topology. Additionally, the SSM **300** may configure an HSE **400** as a supervisory HSE **450**, in both the Access **710** and the Core **720** Network's clusters. The HSE/CHSE network management control subsystem **363** is the set of all executable network management controls defined for both the Access **710** and Core **720** network topologies. The HSE/CHSE Network Management Control Subsystem **363** may maintain the copy of all controls, which may include administrative policies provisioned to the HSE **400**. The FCAPS Service Element Subsystem **365** is the set of executable customized services defined for FCAPS. The FCAPS Service Element Subsystem **365** may maintain a copy provisioned to the HSE **400**.

The Network Element and Operations Support Systems Interface **380** may comprise a Service Provisioning Subsystem **381**, a View Management subsystem **383**, and an Audit-Query subsystem **385**. The Network Element and Operations Support Systems Interface **380** may facilitate real-time communications with the HSE **400**, and communications with an Operating Support Systems (OSS) **390**. The OSS **390** may be autonomous. The Service Provisioning Subsystem **381** may distribute service codes to the HSE **400** in real-time. The process of distribution may include the capability to insert service codes, delete existing service codes or modify components of service codes on the HSE **400**. The View Management Subsystem **383** may create and manage integrated views of an end-to-end network. The View **383** may provide snapshots of the health of the network elements and the network topology. The Audit-Query Subsystem **385** may manage schedule and real-time audits/queries of the HSE **400**. The Audit-Query **385** may be initiated by either the OSS **390** or end-users via the Visual Interface **340**. The OSS **390** computes the detailed network management analysis of the Access **710** and Core **720** network clusters.

With reference to FIG. **14** is an alternate non-limiting embodiment of the SSM **300**. This embodiment of the SSM **300** may comprise three subsystems, a service manager subsystem (ServiceMS) **301**, a sensor manager subsystem (SensorMS), and a network element subsystem (NetworkES) **303**. The ServiceMS **301** may comprise a Fault manager, a configuration manager, an Accounting manager, a Performance manager, a Security manager (collectively referred to as "FCAPS") **1410**, a FCAPS database **1415**, a Control manager **1420**, and a Controls database **1425**. Each manager in the FCAPS **1410** may manage its own services. Each manager **1410** in the FCAPS **1410** may modify its own services. Modify means to create a mapping of what services exist in a given node. Each manager **1410** knows the mapping of where each service or services is deployed. Similarly, the control manager **1420** has a mapping of what types of controls are deployed at each node. Typically only management services are performed in the ServiceMS **301**. For example, the states identified in FIG. **16** Table 1.0 may be monitored in the ServiceMS **301**. The monitoring may provide the ServiceMS **301** with attributes of what service resides on what node, the type of node, and what the current state of the node may be. The SensorMS **302** may comprise a Sensor Manager **1430** and a Sensor database **1435**. The Sensor Manager **1430** may perform provisioning, auditing or sensor service management. The SensorMS **302** may take the service that resides on the SSM **300** and provision the services on different nodes. The sensor database **1435** has a database of all the sensor services and where it may reside. The sensor manager **1430** may also initiate an audit of the sensors to verify what state they are in (i.e. active state, valid state). For example, if a user wants to retire a service, the sensor manager **1430** will perform an audit to see if the service exists on a given sensor. Once the results are returned from the audit, additional steps are taken to implement a service. The NetworkES **303** may comprise a Sensor Network Manager (**1440**), a Sensor Network Topology Database **1445**, and an OSS Manager **1450**. The Sensor Network Topology Database **1445** may provide the NetworkES **303** with information on how network clusters are arranged. An additional illustration of a real-time network management of a cluster and the inner-workings of the NetworkES **303** is shown in FIG. **9**. With reference to FIG. **9**, the HSE **400** or Supervisory HSE **450** (not shown) controls the sensors. The HSE **400** may send bit patterns to the NetworkES **303** or the SSM **300**. This information may be stored in the Sensor Network Topology Database **1445** for a particular core network. The Sensor Database **1435** keeps at least two types of records. The current state and the previous state of the HSE **400**. The previous state deployed is located in the sensor database **1435** and may be time stamped as to when the data was collected. The SensorMS **302**, may provide a time stamped view of the core network to the OSS **390** or to the OSS manager **1450** who transmits the view to the OSS **390**. The OSS **390** may then analyze the results and displays graphical simulations of traffic in the core network. Also the ServiceMS **301** may provide a definition of HSE **400** in the core network topology to the OSS **390** or it may go through the OSS manager **1450**. Additionally, the OSS Manager **1450** may communicate with an OSS **390** via a GUI. It is possible to have a number of OSS **390** within the Model **100**. If different OSSs **390** are present, there may be different interfaces to different protocols supporting the different OSSs **390**. For example, when there is a query to determine what a network comprises, the sensor network topology database **1445** provides snapshots of each sensor attribute. These snapshots may reside within the sensor network topology database **1445**, or may be delivered as a result of various information contained within the sensor network topology database **1445**. The information from the sensor network topology database **1445** in then communicated to the OSS **390**, either directly or via the OSS manager **1450**, by pulling the information from the sensor network topology database **1445**, or pushing the information from the NetworkES **303**.

4. Heterogeneous Sensor Entity (HSE)

With reference to FIG. **6**, an embodiment of a Heterogeneous Sensor Entity (HSE) **400**, which may be embedded in an environment, such as a computer network, nodes, or network elements (i.e. routers including edge routers, core and access routers for example, switches, servers, or multiplexers may be used with sound engineering judgment). The HSE **400** may be dependant or independent of the device's hardware component. The architecture of the HSE **400** may comprise two distinct layers, a Service & API Platform (SAP) **410**, and a HSE runtime service environment (RTSE) **420** as illustrated in FIG. **6**. Runtime environment is an environment which may provide support services for processes or programs on a node. The SAP **410** is a middleware that may be embedded in a host and residing in a given node. The SAP **410** may provide support to the RTSE **420**, and may provide access to the network protocols that already exists in the node. This support may include providing the RTSE **420** with privileged access to low-level host Operating System calls, utilization of the transport protocols and abstraction of the host hardware device. For example, when a system is running, there are specific functions that a user cannot be able to perform based on their level of access. The level of access not granted to a user is called a privilege access to the lower level protocols. Privilege access are functions that only a user labeled level 1 or level 0 can perform. 1 meaning you can perform a function, where 0 means you cannot perform a function. The 1 to perform or 0 not to perform a function may be reversed based on the desire of the programmer. The SAP **410** may provide the FCAPS and Control manager with privilege access to these lower level protocols. The SAP **410**, having such access, becomes an integral part of the host due to this permission being granted while the system is running. Additionally, the SAP **410** may provide the RTSE **420** with runtime data-structures of pertinent host applications. Data structure means the application make-up/mapping. This allows the API to emulate the service, because it has this access to the structure. The RTSE **420** may provide support to the applications after the services are running on the nodes. The RTSE **420** may contain the executable network management services and controls. The executable services may be turned on/off via a host application layer (e.g. browser interface) if desired. The RTSE **420** may emulate the host applications and host hardware devices for fault, configuration, accounting, performance and security. The RTSE **420** may activate prescribed network management controls to enforce load balancing in real-time, and it may remove controls when the network traffic transitions to a stable state.

With reference to FIG. **13**, is another non-limiting embodiment of the HSE **400**. In this non-limiting embodiment, the HSE **400** may comprise an Application Layer **1310**, a Message Transport Layer (MTL) **1320**, a Control Management Layer **1330**, and a Low-Level Hardware Dependant Application Programming Interface (API) **1340** as illustrated in FIG. **13**. The application layer **1310** hosts the service elements provisioned by the SSM **300**. The Application Layer **1310** provides the runtime environment to emulate designated hardware device operations and to execute Decision Graphs. The MTL **1320** provides low-level messaging and Input/Output (I/O) communication. For example the MTL **1320** provides I/O for HSE **400** peer-to-peer, HSE **400** to HSE **450**, HSE **400** to SSM **300**, and Supervisory HSE **450** to SSM **300** communications. The Control Management Layer **430** implements, activates, and removes network management controls. The network control activation and removal is based on real-time performance data. For example, when the HSE **400** or supervisory HSE **450** detects an internal stimulus, it analyzes the performance data, then the controls are activated or removed depending on the results of the real-time analysis. One purpose of having the ability to activate, remove and modify controls is to keep network operation near max efficiency under network anomalies, and to alter network traffic flow based on admin policies and objectives. The Lower-Level Hardware Dependent API **1340** provides an abstraction of hardware resources for measuring functions. These functions may include fault, configuration, accounting, performance, and security metrics. The HSE **400** stores network administrative policies in directories, and retrieves and interprets administrative policies prior to implementing network management controls. The HSE **400** hosts customized network management service elements, and provides runtime environment for autonomous network management monitoring and control function. The HSE **400** behavior is based on its managed device's state and local surroundings, each state and surrounding may have different characteristics from other managed devices within the same cluster. Additionally the HSE **400** may be provisioned by the SSM **300** with supervisory functioning capabilities for managing HSE(s) **400** in its network cluster. Each network cluster may include a supervisory HSE **450**, which coordinates the network management and control activity of the HSE **400** within its network cluster. An example of a benefit of having a supervisory HSE **450** is when an HSE **400** located within a cluster becomes unreachable. The supervisory HSE **450** may now serve as a conduit to the remainder of the Model **100**. The architecture of the supervisory HSE **450** may be identical to the architecture of the HSE **400**. Additionally, HSE **400** may communicate with additional HSE(s) **400** in real-time, which may prevent the system from overloading or experiencing congestion. For example, FIG. **10** illustrates the HSE **400** assisting with Automatic Congestion Control (ACC). When the node level cycle exceeds a predetermined length of time to complete assigned tasks, for reason such as additional work load, the HSE **400** senses the congestion within the node, sends ACC indicators bit-mapped vectors to an HSE **400** or supervisory HSE **450**, depending on the framework, and the neighboring HSE(s) **400**. The HSE **400** may instruct other HSEs **400** to avoid using the node a form of facilitating traffic. In real-time the other nodes will take the troubled node off of the routing table, and tells the other nodes to use a secondary route until the trouble node responds saying it is okay to continue traffic using the once troubled node. The supervisory HSE **450** or the neighboring HSE(s) **400** or both may activate controls that normalize the node in real-time. Additionally, the HSE **400** or Supervisory HSE **450** may activate controls to reroute traffic around the Access Gateway until the congestion in the network is resolved. Once the node base level cycle takes its normal time to complete the assigned task, the HSE **400** sends normal ACC indicators to the supervisory HSE **450** or neighboring HSE(s) **400** or both, which continues to remove the previously activated controls. Additionally, the HSE **400** communicates with the SSM **300** to facilitate real-time network management and control operations.

Additionally, the HSE **400** may provide abstractions of hardware resources for measuring FCAPS metrics. The HSE **400** detects, counts, and reports parameters using bit patterns (1's and 0's) or by any other means known to a person having ordinary skill in the art. For example, the HSE **400** may send bit patterns to the Supervisory HSE **450** or SSM indicating what type of hardware is experiencing problems. The abstractions allow the HSE **400** to detect faults, network overload traffic, intra-node congestions, adjust configuration, access parameters, and to implement and remove network management controls.

In another non-limiting embodiment the Model **100** further comprises a Supervisory Heterogeneous Sensor Entity (CHSE) **455**. The CHSE **455** may perform real-time communication with the SSM **300**. The architecture and characteristics of the CHSE **455** may be identical to the HSE **400** or supervisory HSE **450**. The CHSE **455** may use the same communication methods as the HSE **400** or the supervisory HSE **450**. The CHSE **455** may be provisioned by the SSM **300** with supervisory functioning capabilities identical to the supervisory HSE **450**. The CHSE **455** may be present in the Access **710** or Core **720** network clusters with other HSE(s) **400** where a supervisory HSE **450** is not present. An example of a schematic illustration of analysis of real-time multimedia network traffic management and control operations is shown in FIG. **11**. With reference to FIG. **11**, the OSS **390** performs a query for a GPRS and a Packet Core Network. This figure shows how the OSS **390** may communicate with different types of networks. Additionally, different networks can communicate with one another using the SSM **300**. For example, the HSE **400** in the GPRS and Packet Core Network detect various counts for the dominant network parameters then notify their respective HSE **400** to perform an analysis of their network cluster. If the GPRS is in trouble, the SSM **300** can sense where the trouble or congestion is coming from, thus making the network is reliable by pinpointing the problem. Each HSE **400** activates network management controls in the cluster based on the analysis. The HSE **400** then sends an update to the SSM **300**. The SSM **300** creates a snapshot of the GPRS and the Packet Core network domains by updating the View **383** of the GPRS and the Packet Core network domains in real-time. The SSM **300** then notifies OSS **390** to perform a detailed network management analysis of the affected network domain. Additionally, both the CHSE and HSE may include two types of executable: FCAPS and Managerial. Any HSE may assume the role of a CHSE when its Managerial and FCAPS executables are both turned ON. In the case when there is an HSE, FCAPS is ON but the Managerial component is OFF.

With reference to FIG. **15**, a Multimedia Network Traffic Management system framework for converged heterogeneous networks is shown. The Model **100** is shown communicating with different network types (i.e. WiMax, LTE, GPRS, GSM Wireless, IMS, PSTN/IN, or any other types of networks known to a person having ordinary skill in the art). Older network types may also communicate using the Model **100** to communicate with similar or newer technologies. Additionally, different network types may communicate with other networks that are different from their own. The HSE **400** may also communicate with neighboring HSEs **400** positioned on different network types. The SSM **300** continuously monitors each different network type in real-time.

With reference to FIG. **17**, a Bit Vector Analysis is shown. The Alarm-Level Indicators may be uniquely identified by the permutations in bit positions **1** and **2**. An originating HSE (or CHSE) may send the Query indicator to recipient HSE to request the status of the recipient's host. Network Management Types may be uniquely identified by the permutations in bit positions **3**, **4** and **5**. The bit positions **6**, **7**, **8**, . . . through "n", map to components (e.g., processes, hardware, application, resources, drivers, external interfaces etc.) **1**, **2**, . . . "n−5" for a given HSE. For example, when the bit value is set to 1, it indicates that the component has an alarm level specified by the permutations in bit positions **1** and **2** for the network management type specified by permutations in bits **3**, **4** and **5**. A zero bit value may indicate optimal functionality of the associated HSE component.

With continued reference to FIG. **17**, and now FIG. **18**, examples of bit vector diagnosis is shown. Example 1 illustrates the sending/originating HSE/CHSE's host in optimal state. Example 2 illustrates the sending/originating HSE/CHSE's host is stable, but a slight performance degradation is detected in component #**3**. Example 3 illustrates a minor alarm in the configuration of component #**4** for sending/originating HSE/CHSE's host. In Example 4, the host HSE (or CHSE) sends a Query message to other HSEs for status of their security levels. In Example 5, the HSE (or CHSE) sends an optimal security levels for its host (Notice that bit positions **6**, **7**, **8**, . . . , "n" are set to 0). In Example 6, the HSE (or CHSE) sends a stable, but less optimal security level due to security status of host's component #**2**. In Example 7, the HSE (or CHSE) sends a minor security alarm indicator associated with the host's component #**1**.

While the invention has been illustrated and described with respect to various examples and applications (i.e. use with 4G networks), the same is to be considered as illustrative and not restrictive in character. Older networks types (i.e. 1G-3.5G etc.) that may be operable in specific areas are still capable of being managed by the invention described herein, and it being understood that only illustrative embodiments thereof have been shown and described. All changes and modifications that come within the spirit of the invention described by the following claims are desired to be protected. Additional features of the invention will become apparent to those skilled in the art upon consideration of the description. Modifications may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A method for real-time management of wireless and converged networks, comprising steps of:

determining a network topology including a plurality of network clusters having a plurality of network elements;

providing a management system to define and maintain a master copy of network configurations, sensor attributes and said plurality of network elements;

said management system deploying sensors to the plurality of network elements, wherein each of said sensors emulates a respective element to which each of said sensors is deployed;

said sensors determining which information items of said network elements are of a type which must change in real-time based on a pre-emptive diagnostics of said network elements and said network clusters;

said sensor systems generating instructions to the management system and other sensors using bit mapped vectors to represent a real-time status of said network elements, and one or more of fault, configuration, performance, accounting, security, and control network management types and services in the wireless and converged networks and controls, and non-optimal components of network elements;

responsive to said instructions from said sensor systems, a plurality of recipient sensors performs real-time analysis and determines corrective actions to maintain optimal network operations and network services;

responsive to said real-time analysis, said recipient sensors provide real-time information to said management system;

responsive to said real-time analysis from said recipient sensors, said management system updates the master copy of the network topology and said network element attributes; said management system instructs operation support systems about the real-time status of the network and components of the said network elements; and wherein said management system is configured to create a service element based on a requirement of a sensor entity;

identifying a supervisory sensor for each of said plurality of network clusters among said sensors;

determining at least one of said sensors is an unreachable sensor; and

routing traffic around said unreachable sensor through said supervisory sensor to manage communication among said sensors and across network clusters and network elements in response to said determination.

2. The method of claim **1** further comprising a step of: said sensor systems performing real-time control of heterogeneous streams of services in the wireless and converged networks.

3. The method of claim **1** further comprising the steps of:

said management system performing real-time provisioning of one or more heterogeneous streams of network management types and services in the wireless and converged networks.

4. The method of claim **1** further comprising the step of:

a service creation system and said management system performing service version management for network management types and service instances.

5. The method of claim **1**, wherein the supervisory sensor manages communication routing between and among said sensors and said management system.

6. The method of claim **1**, further comprising:

diagnosing a fault, configuration, security failures, and performance degradation in real-time based on shared intelligence between two or more of said sensors based on the one or more of the network management types and services; and

correcting fault, configuration, security failures, and performance degradation in real-time based on said shared intelligence between the two or more of said sensors based on the one or more of the network management types and services.

7. A network management system for real-time management of wireless and converged networks comprising:

a management system having at least a first sensor service configured to define and maintain a master copy of network configurations, sensor attributes and network elements;

a network topology database including network topology information related to said network elements and one or more network clusters that facilitates data sharing between at least said network elements;

a plurality of sensors each configured to respectively emulate one of said network elements;

said sensors further configured to determine which information items of said network elements are of a type which must change in real-time based on a pre-emptive diagnostics of said network elements and said network clusters;

said sensors configured to generate instructions to the management system and other sensors using bit mapped vectors representative of the real-time status of network elements, and one or more of fault, configuration, performance, accounting, security, and control network management types and services in the wireless and converged networks, and controls, and non-optimal components of network elements;

a recipient sensor responsive to said instructions from said first sensor service and configured to perform a real-time analysis and determine corrective actions to maintain optimal network operation and network services;

said management system configured to update the master copy of the network topology database in response to reception of topology information related to one or more of said network elements from said sensors emulating said network elements, said network element attributes in response to said instructions from said sensor service;

said sensor service configured to instruct operation support systems about the real-time status of the network and components of the said network elements;

wherein said management system is configured to create a service element based on a requirement of a service entity; and

a supervisory sensor for each of said plurality of network clusters among said sensors;

a determination that at least one of said sensors is an unreachable sensor; and

wherein traffic is routed around said unreachable sensor through said supervisory sensor to manage communication among said sensors and across network clusters and network elements in response to said determination.

8. A system, comprising:

a service creation system that creates at least one service performing a network management task for a wireless and converged networks;

a management system to define and maintain a master copy of network configurations, sensor attributes and said plurality of network elements;

a topology database of the management system that describes a network topology of the network to the management system and one or more network clusters that facilitate data sharing between at least said network elements;

sensors deployed to the plurality of network elements, wherein each of said sensors emulates a respective element to which each of said sensors is deployed to produce performance data related to the network;

said sensors further configured to determine which information items of said network elements are of a type which must change in real-time based on a pre-emptive diagnostics of said network elements and said network clusters;

said sensors generating instructions to the management system and other sensors using bit mapped vectors to represent a real-time status of said network elements, and one or more of fault, configuration, performance, accounting, security, and control network management types and services in the wireless and converged networks and controls, and non-optimal components of network elements, wherein said management system updates the master copy of the network topology and instructs operation support systems about the real-time status of the network and components of the said network elements; and wherein said management system is configured to create a service element based on a requirement of a sensor entity;

a supervisory sensor for each of said plurality of network clusters among said sensors;

said supervisory sensor determining if at least one of said sensors is an unreachable sensor; and

causing the rerouting of traffic around said unreachable sensor to manage communication among said sensors and across network clusters and network elements in response to said determination.

9. The system of claim **8**, wherein the at least one service is selected from a group consisting of fault management, configuration management, accounting management, performance management, and security management and combinations thereof.

10. The system of claim **8**, further comprising a control system for controlling two or more network nodes that facilitates substantially real-time end-to-end network management by modifying operation of at least one of the two or more network nodes.

11. The system of claim **8**, further comprising a new node system that generates a new sensor entity based at least in part on detection of a new node and a node type of the new node.

12. The system of claim **8**, wherein the management system deploys the at least one service to two or more network nodes in the network, and two or more sensor entities emulate the two or more network nodes.

13. The system of claim **12**, further comprising:

a template creation system that creates at least one node template to emulate the two or more network nodes; and

a template database that stores the at least one node template.

14. The system of claim **13**, wherein the template creation system creates the node template to emulate a new node of an unknown node type based at least in part on detection of the new node and one or more processes running on the new node.

15. The system of claim **12**, wherein the two or more network nodes are of a known node type, the known node type includes an identification of one or more signaling systems, routers, switches, servers, multiplexers, Customer Premise Equipment, personal computer systems, PDAs, mobile devices, cell phones and combinations thereof.

16. The system of claim **12**,

wherein said network cluster having a plurality of nodes;

and a supervisory sensor entity that receives emulated node data from at least one sensor entity and provides the emulated node data to at least the management system.

17. The system of claim **16**, further comprising a supervisor selection system that selects the supervisory sensor entity based on one or more of connectivity outside the network cluster, a traffic level of a node among the two or more network nodes, and a node type of the node among the two or more network nodes.

18. The system of claim **16**, wherein the supervisory sensor entity further manages traffic routing between the two or more network nodes.

19. The system of claim **12**, wherein a first sensor entity among the two or more sensor entities transmits node information related to a first network node among the two or more network nodes to a second sensor entity among the two or more sensor entities.

20. The system of claim **19**, wherein the second sensor entity is a supervisory sensor entity.

21. The system of claim **19**, wherein the node information includes at least traffic information related to the first network node.

22. The system of claim **12**, further comprising an analysis system of the two or more sensor entities that analyze traffic related to the two or more network nodes in real-time.

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