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(54) **TELECOMMUNICATIONS SYSTEM HAVING SEPARATE SWITCH INTELLIGENCE AND SWITCH FABRIC**

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Related U.S. Patent Documents

(57) **ABSTRACT**

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The present invention is a telecommunications system having separate switch fabric and switch intelligence. The system comprises a switch fabric, a switch intelligence, and a feature processor. The switch intelligence is logically separated from the switch fabric and comprises a switch fabric proxy, a facility service, a connection manager service, and a call segment instance service. The switch fabric proxy is coupled to the switch fabric via a vendor-specific first Application Programming Interface (API). The switch fabric proxy supports a second API, which is common across all vendors, representing functions supported by the switch fabric. A facility instance, which is instantiated by a facility service using a facility model, represents the bearer and signaling facilities of a party to a call, and interacts with the switch fabric proxy via the second API to communicate with the switch fabric. The connection manager service represents the connectors for a party to a call, and interacts with the switch fabric proxy via the second API to communicate with the switch fabric. A call segment instance service using a call model, represents the call logic and call data for a party to a call, and interacts with the connection manager service via a third API and with the facility instance via a fourth API. The feature processor interacts with the call segment instance via a fifth API to provide the telecommunications feature.

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See application file for complete search history.

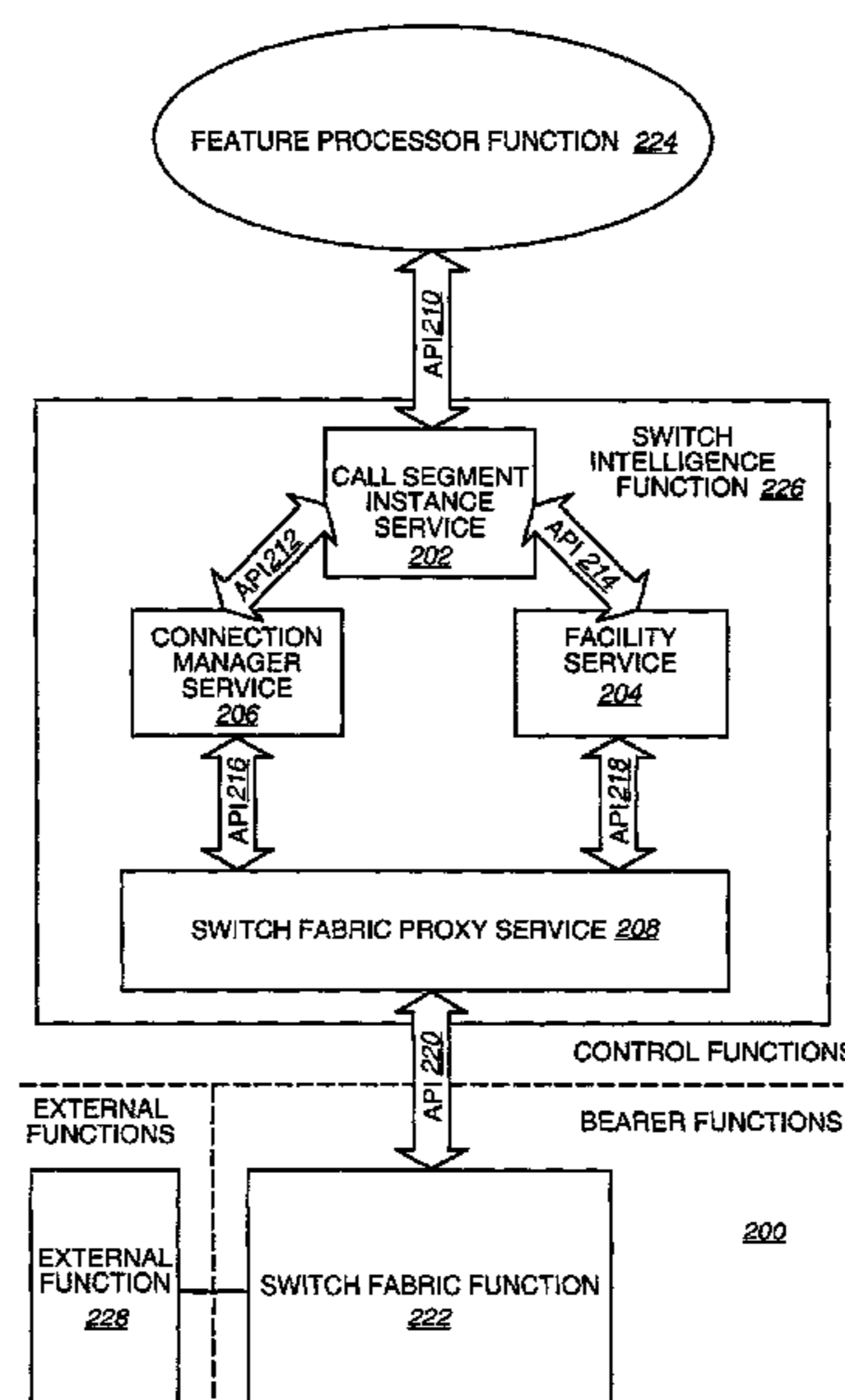
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58 Claims, 5 Drawing Sheets



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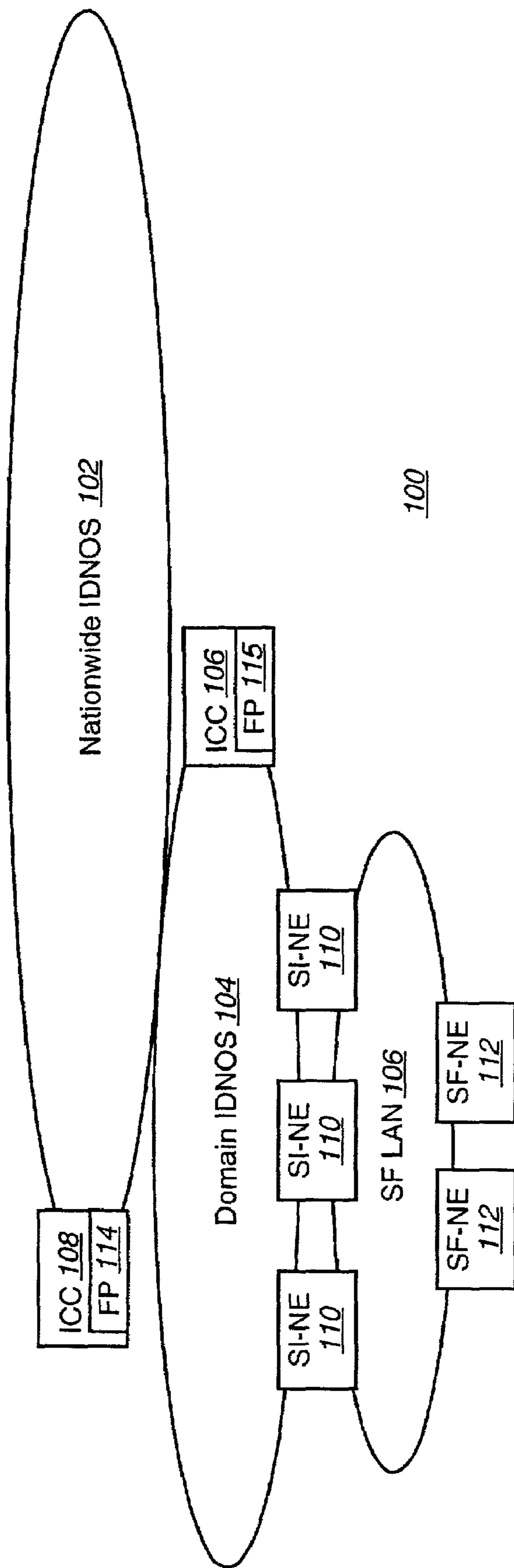


FIG. 1

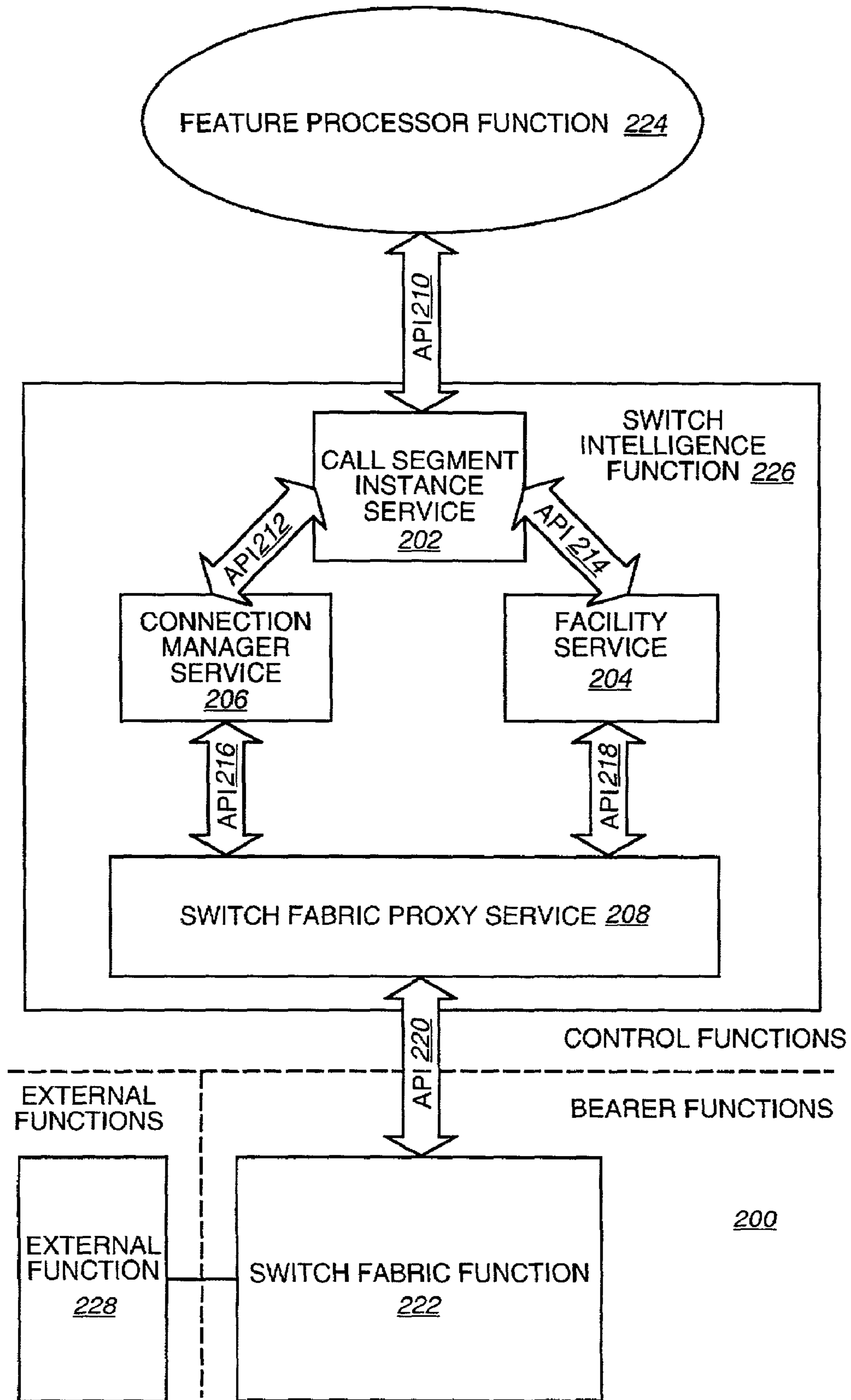


FIG. 2

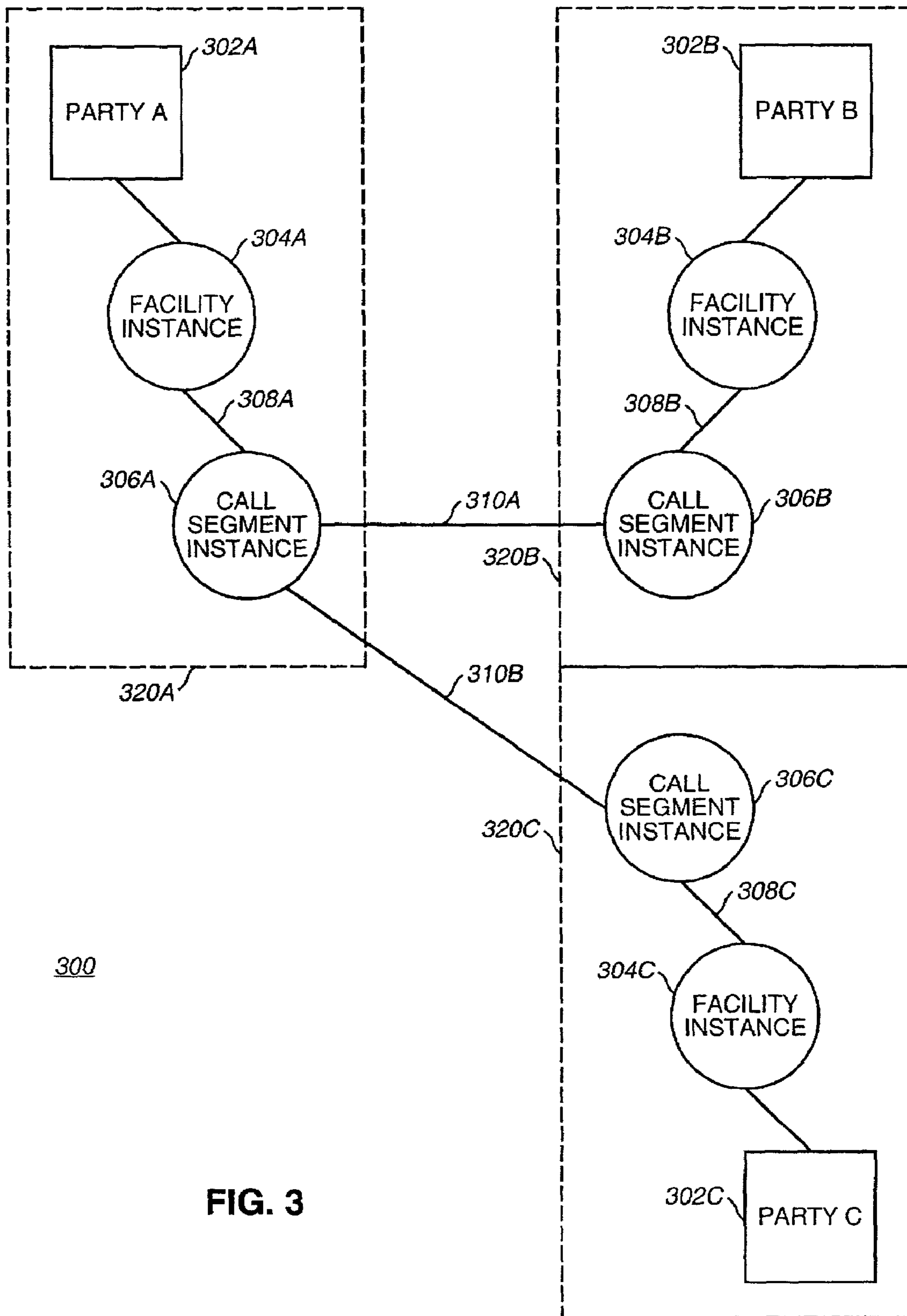


FIG. 3

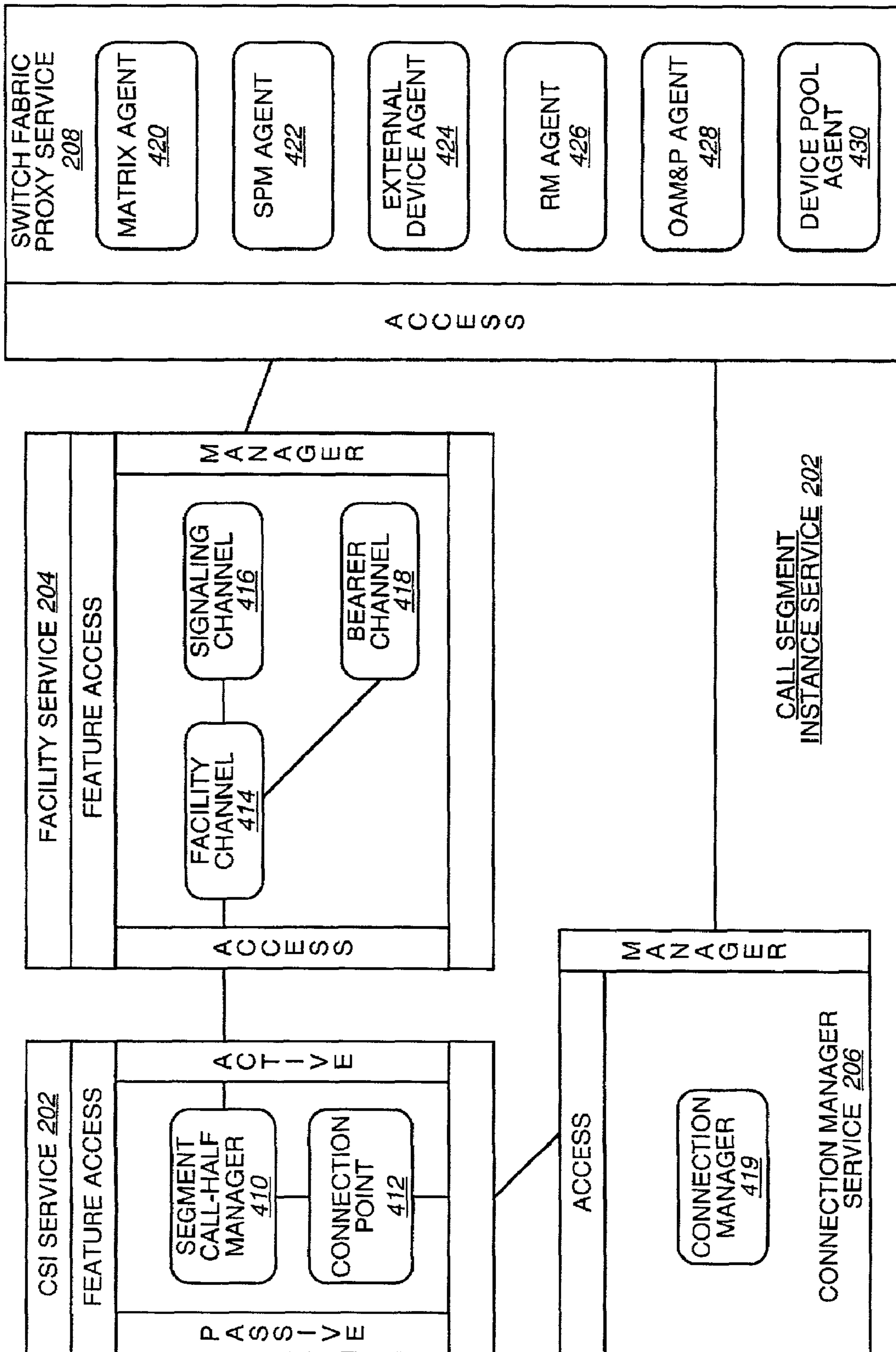


FIG. 4

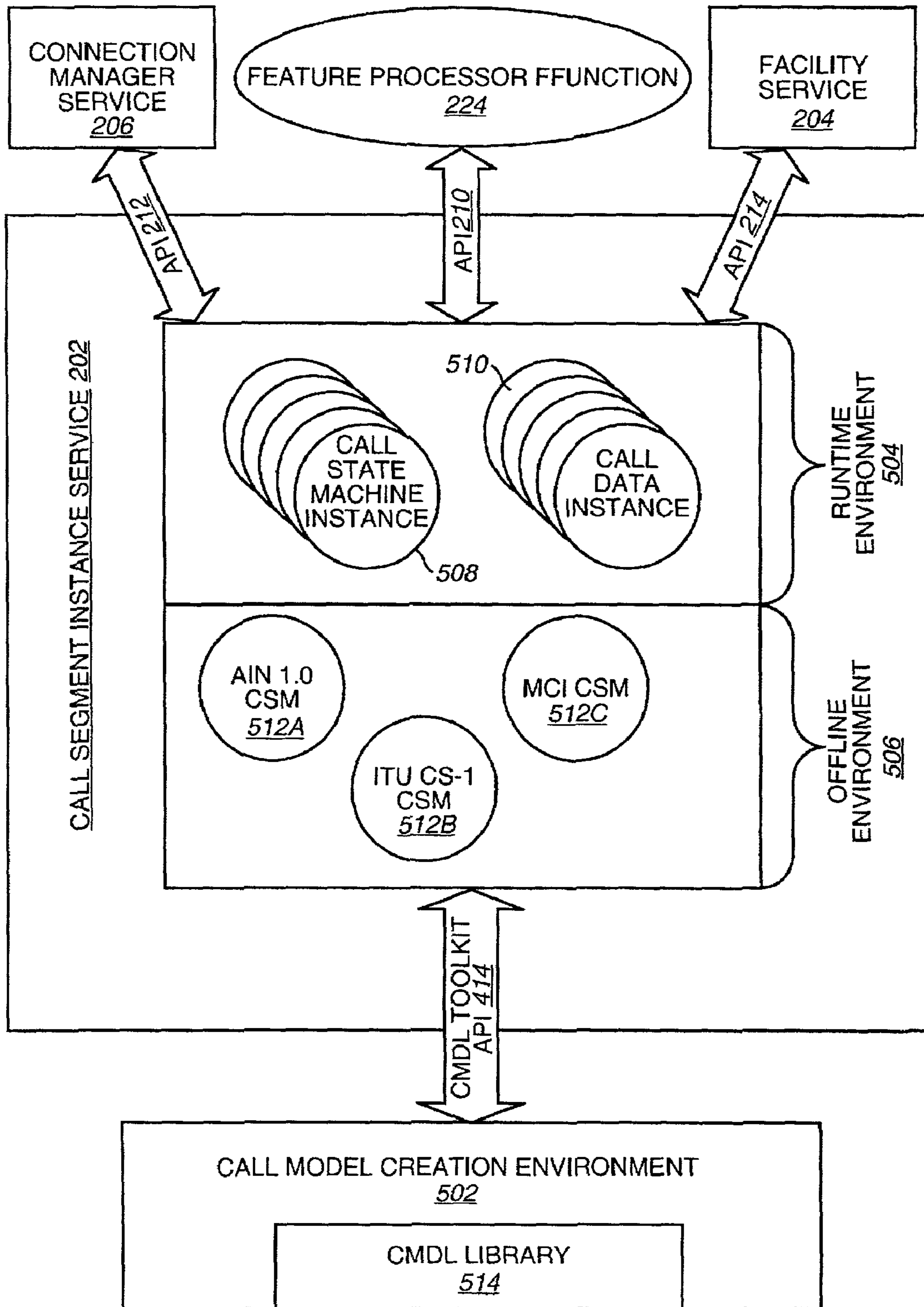


FIG. 5

**TELECOMMUNICATIONS SYSTEM HAVING
SEPARATE SWITCH INTELLIGENCE AND
SWITCH FABRIC**

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to network switching and more particularly to a telecommunications system having separate switch intelligence and switch fabric.

2. Related Art

A conventional telecommunications network comprises three basic components: user terminals (e.g., telephones), communications busses (e.g., telephone lines) and switches. The switches are used to selectively connect the user terminals via the communications busses. Each switch comprises two basic components: the switch fabric, which physically interconnects the communications busses, and the switch intelligence, which directs the operation of the switch based on control signals (e.g., telephone numbers) received by the switch.

In recent years, however, the telecommunications features offered by service providers (including both local and long distance service providers) have increased dramatically in both number and complexity. Because many of these features are implemented primarily at the switch, the complexity of the switch intelligence has increased in kind to include complex call processing logic. Despite the dual nature of the switch, standard telecommunications architectures such as Advanced Intelligent Network (AIN) and SS7 have continued to incorporate both switch intelligence and switch fabric into a single device. The retention of this monolithic switching approach in the face of these changes has substantial disadvantages.

The primary disadvantages result from the fact that switches from different manufacturers may employ unique methods of control and/or unique computing languages in their switches. Thus when a service provider offers a new feature requiring a change in switch intelligence, the change must be implemented by the switch vendor. In a network comprising switches from several manufacturers, these changes must be coordinated to ensure a coincident release of the new feature at all switches. Further, each switch vendor must implement a switch change required by one service provider without disturbing the switch intelligence aspects required by other service providers. Finally, changes cannot be implemented centrally, but must be implemented separately at each switch. This arrangement requires substantial lead time for a change, typically on the order of two years or more.

What is needed, therefore, is a telecommunications network where the switch intelligence is separated from the switch fabric.

SUMMARY OF THE INVENTION

The present invention is a telecommunications network having separate switch fabric and switch intelligence. The system comprises a switch fabric, a switch intelligence, and a feature processor. The switch intelligence is logically separated from the switch fabric and comprises a switch fabric

proxy, a facility service, a connection manager service, and a call segment instance service. The switch fabric proxy is coupled to the switch fabric via a vendor-specific first Application Programming Interface (API). The switch fabric proxy supports a second API, which is common across all vendors, representing functions supported by the switch fabric. A facility instance, which is instantiated by a facility service using a facility model, represents the bearer and signaling facilities of a party to a call, and interacts with the switch fabric proxy via the second API to communicate with the switch fabric. The connection manager service represents the connectors for a party to a call, and interacts with the switch fabric proxy via the second API to communicate with the switch fabric. A call segment instance, which is instantiated by a call segment instance service using a call model, represents the call logic and call data for a party to a call, and interacts with the connection manager service via a third API and with the facility instance via a fourth API. The feature processor interacts with the call segment instance via a fifth API to provide the telecommunications feature.

The switch intelligence further comprises two call processing creation environments. The first, called a call model creation environment, is employed to access the call segment instance service via a programming API to modify existing call models and to create new call models. The second call processing creation environment is employed to access the facility service via a programming API to modify existing facility models and to create new facility models.

One advantage of the present invention is to facilitate rapid creation and deployment of new telecommunications features.

Another advantage of the present invention is to allow software and hardware components to be reused across multiple features and products.

Another advantage of the present invention is to permit scalability both at the processor level and at the level of the communications infrastructure.

Another advantage of the present invention is to provide an architecture that is reusable across future switch and port infrastructures (for example, broadband).

Another advantage of the present invention is to provide an infrastructure that supports the ability to engineer applications in varying levels of centralization or distribution, based on usage.

Another advantage of the present invention is to define a call processing environment in which buy/build decision can be made on major components of the call processing system, including facilities, signaling, and call data processing.

Another advantage of the present invention is to define a call processing environment in which the price/performance decisions of the switch call processing and switch hardware capabilities are decoupled, resulting in an optimized business buying strategy.

Further features and advantages of the present invention as well as the structure and operation of various embodiments of the present invention are described in detail below with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements. Additionally, the left-most digit of a reference number identifies the drawing in which the reference number first appears.

BRIEF DESCRIPTION OF THE FIGURES

The present invention will be described with reference to the accompanying drawings, wherein:

FIG. 1 is a network block diagram depicting the major components of a network according to a preferred embodiment of the present invention;

FIG. 2 is a functional block diagram of a switch node embodying a switching function according to a preferred embodiment of the present invention;

FIG. 3 is an object view of a three-way call as an instance of the call model according to a preferred embodiment of the present invention;

FIG. 4 is an object view of the conceptual elements contained within the services according to the present invention; and

FIG. 5 is an object view of Call Segment Instance Service according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

I. Introduction

The preferred embodiment of the invention is discussed in detail below. While specific steps, configurations and arrangements are discussed, it should be understood that this is done for illustrative purposes only. A person skilled in the relevant art will recognize that other steps, configurations and arrangements can be used without departing from the spirit and scope of the invention.

II. The Intelligent Distributed Network Architecture

As used herein, the Intelligent Distributed Network Architecture (IDNA) defines the infrastructure and network elements of an advanced switching system. The term network element (NE) is used herein to describe any physical device within the IDNA. An NE within the IDNA is named according to its primary function. Therefore, an NE that performs primarily switch intelligence functions is named a Switch Intelligence Network Element (SI-NE). A functional entity (such as switch intelligence) may be split across multiple NEs, in which case all of the NEs are denoted by their primary functions (such as SI-NE).

FIG. 1 is a network block diagram depicting the major components of a network according to a preferred embodiment of the present invention. Referring to FIG. 1, network 100 comprises a Nationwide Intelligent Distributed Network Operating System (IDNOS) 102 and a plurality of Domain IDNOS 104 (only one Domain IDNOS 104 is shown). IDNOS 104 is the infrastructure supporting the communications, execution, and maintenance of processes within network 100. IDNOS is essentially similar in nature to DCE client/server application environments or CORBA distributed object execution environments.

Each Domain IDNOS 104 is coupled to Nationwide IDNOS 102 and at least one Intelligent Computing Complex (ICC) 108. ICC 108 is a computing element that provides services to control the calls processed by Switch Intelligence NEs 110. Each ICC 108 comprises at least one Feature Processor 114. Feature Processor 114 is the functional entity which contains all IN-style logic associated with call processing. This logic is all logic which controls advanced call services and call structure, and may overlap the logic of Switch Intelligence NE 110 in areas where rapid service creation has forced this structure. Feature Processor 114 is usually thought of as comprising all logic not associated with either signaling or call models.

Each Domain IDNOS 104 supports a switching function comprising at least one Switch Intelligence NE 110 coupled to at least one Switch Fabric NE 112. Switch Intelligence NEs 110 are the elements of network 100 that provide call processing functions to manage and process the facilities pro-

vided by Switch Fabric NEs 112. Switch Intelligence NE 110 contains all aspects of data processing required to complete a simple bearer connectivity request, as well as all logic required to determine points in call where feature involvement is required. Switch Intelligence NE 110 can be a general-purpose computer, such as a Sun or HP Workstation.

Switch Fabric NE 112 is the element of network 100 that provides the physical facilities necessary to complete a call. These resources include, but are not limited to, bearer devices (T1's, DS0's), network matrix devices (network planes and their processors), link layer signal processors (SS7 MTP, ISDN LAPD), and specialized circuits (conference ports, audio-tone-detectors). Switch Fabric NE 112 represents the hardware switch component provided by a switch manufacturer, such as Nortel.

In a preferred embodiment, network 100 is implemented as a client-server system using functional application programming interfaces (APIs) defined for each service. For example, if an application running on a SI-NE 110 requires a service provided by a FP 114, the SI-NE 110 acts as a client to request the service via an API, and the FP 114 acts as a server to provide the service. Conversely, if an application running on a FP 114 requires a service provided by a SI-NE 110, the FP 114 acts as a client to request the service via an API, and the SI-NE 110 acts as a server to provide the service.

Each call to a server is made through these APIs, regardless of the geographic separation between the client and server. IDNOS 102 allows the client and server to be separated geographically across IDNOS-compatible interfaces and provides a remote procedure call (RPC) capability that is transparent to the client and the server. Thus, applications can be designed as though both client and server were in the same processor, independent of the actual underlying RPC mechanism. Thus, the present invention provides location transparency.

This functional interface method is substantially different from the message-based interfaces provided by traditional IN architectures. These interfaces typically assume a specific distribution topology, and require an underlying infrastructure that is inherently tied to a particular communications method (CCS7, MTP, etc.). The RPC-based approach employed in network 100 allows the underlying communications method to be evolved independently of the design of upper-layer clients and servers.

The RPC client-server model is restricted to interfaces at the service level. Interfaces within the actual servers (between components of the server) are vendor-proprietary, and are not subject to this specification.

In one embodiment, the present invention is implemented as computer software embedded in a computer usable medium as computer readable program code means. The computer usable medium can be, for example, a hard disk drive or a removable storage medium such as a floppy disk.

A. IDNA Services

FIG. 2 is a functional block diagram of a Switch Node 200 embodying a switching function according to a preferred embodiment of the present invention. This functional view can be thought of as a cross-section of network 100 that shows how the switching functions deployed onto network elements interact to provide telecommunications features according to a preferred embodiment of the present invention. Switch Node 200 is a logical entity implemented as functions which are executed by the physical network elements depicted in FIG. 1. Each function may be provided by one or more NEs. For example, Switch Fabric Function 222 may be provided by one Switch Fabric NE 112, or may be distributed over two or more Switch Fabric NEs 112.

For clarity, the depiction of Switch Node **200** is divided into bearer functions and control functions. The control functions comprise Feature Processor Function **224** and Switch Intelligence Function **226**. Switch Intelligence Function **226** further comprises Call Segment Instance Service **202**, Facility Service **204**, Switch Fabric Proxy Service **208**, and Connection Manager Service **206**. The bearer functions comprise Switch Fabric Function **222**. For ease of explanation, FIG. **2** also depicts external functions comprising External Function **228** (for example, a PBX function).

Switch Fabric Proxy Service **208** is a device driver preferably supplied by the manufacturer of the Switch Fabric NE(s) executing Switch Fabric Function **222**. Switch Fabric Proxy Service **208** provides Connection Manager Service **206** and Facility Service **204** with a common interface to Switch Fabric Function **222** and a common view of the services provided by Switch Fabric Function **222**.

In a preferred embodiment, the interface between Switch Fabric Proxy Service **208** and Switch Fabric Function **222** is a vendor-specific ATM interface, and the interface between Call Segment Instance Service **202** and Facility Service **204** is an ISDN variant Q.931.

Call Segment Instance Service **202** is the process which actually brings up and takes down individual connections to complete a call. Facility Service **204** is a protocol state machine that provides all data processing related to the physical resources (that is, facilities) involved in a call. As discussed below, Call Segment Instance Service **202** and Facility Service **204** are programmable to generate a call model which provides a run-time environment for Feature Processor Function **224** to establish calls.

Connection Manager Service **206** rationalizes abstract connection requests from Call Segment Instance Service **202** and resolves these requests into physical connection requests to Switch Fabric Function **222**. For example, Connection Manager Service **206** will receive a request to make a particular connection, and translate this request into a request to Switch Fabric Function **222** to physically connect two particular ports.

Services **202**, **204**, and **206** are not instances, but rather monolithic services which maintain instances within themselves to establish a particular call segment. Each of the services described herein fulfills the interfaces described within this specification using specific procedures. However, as will be apparent to one skilled in the relevant art, other procedures will satisfy the interfaces described, so long as all of the API-specified interfaces are satisfied.

As stated above, the switching function is divided into two primary functions: Switch Intelligence Function **226** and Switch Fabric Function **222**. These two functions cooperate in a client/server relationship to complete requests for bearer connectivity (e.g., phone calls). A fundamental conceptual distinction between Switch Intelligence Function **226** and Switch Fabric Function **222** is the assignment of data and devices. All devices necessary to complete a bearer connectivity, including trunk cards, switch matrix networks, specialized circuitry, and link processor cards, are assigned to Switch Fabric Function **222**. All data (i.e., processing of information) from these devices, including the processing of signaling, call state, and feature request information, is assigned to Switch Intelligence Function **226**.

As stated above, Switch Intelligence Function **226** and Switch Fabric Function **222** correspond logically to two physical computing devices called Network Elements (NEs). Switch Intelligence Function **226** resides within one or more

Switch Intelligence NEs (SI-NEs) **110**, whereas Switch Fabric Function **222** resides within one or more Switch Fabric NEs (SF-NEs) **112**.

Communication between these SF-NEs and SI-NEs is performed using an interface which is preferably supplied by the manufacturer of the Switch Fabric Function **222**. This interface consists of Switch Fabric Proxy Service **208** and API **220**. Switch Fabric Proxy Service **208** is a software element, usually residing on an SI-NE, which provides a normalized interface to the functional elements of Switch Intelligence Function **226**. Switch Fabric Proxy Service **208** permits SF-NE vendors to use any control interface between an SF-NE and Switch Fabric Proxy Service **208** (API **220**), but forces SF-NE vendors to provide a uniform interface from Switch Fabric Proxy Service **208** to Switch Intelligence Function **226** (APIs **216** and **218**). Requests flow between Switch Intelligence Function **226** and Switch Fabric Proxy Service **208** as API procedure calls and responses defined by APIs **216** and **218**. As will be apparent to one skilled in the relevant art, APIs **216** and **218** can be considered to be two portions, perhaps overlapping, of a single API.

1. The IDNA Call Model

The IDNA call model is a method of representing the bearer, signaling, and call processing facilities associated with a call. FIG. **3** is an object view of a three-way call **300** as an instance of the call model according to a preferred embodiment of the present invention. The call model described in this specification is based on several fundamental concepts.

A call is composed of a number of participating members, one for each party to a call; each member is known as a "call half." A call half provides all control for the facilities, subscribers, databases, and call states for the participating member. Call **300** comprises three parties **302A-C**, and thus three call halves **320A-C**.

Each call half **320** is composed of two primary elements: Call Segment Instance **306** and Facility Instance **304**. Call Segment Instance **306** is an instance of Call Segment Instance **202**. Call Segment Instance **306** supports the data and interfaces required for call state, subscriber, and feature processing. Call Segment Instance **306** represents the processing of an endpoint in a call. Facility Instance **304** is an instance of Facility Service **204**. Facility Instance **304** supports the processing of events on a facility and correlates these events into requests to Call Segment Instance **306**.

The processing of data related to physical facilities, contained within Facility Instance **304**, is isolated from the actual physical facilities contained within Switch Fabric NE **112** (represented by Switch Fabric Proxy Service **208**). Switch Fabric NE **112** provides minimal data processing capabilities.

FIG. **4** is an object view of the conceptual elements contained within the services according to the present invention. In the following discussion, a distinction is drawn between services, which are real and defined, and conceptual entities, which are provided for illustrative purposes only.

The following paragraphs define the services of Switch Intelligence Function **226** according to a preferred embodiment of the present invention, as well as the conceptual entities contained within these services, with reference to FIG. **3**.

2. The Call Segment Instance Service

Call Segment Instance Service **202** is the IDNOS service that performs call half processing, and is the entity that represents the status of call half **302**, including all connection points and associated resources. Call Segment Instance Service **202** communicates to Facility Service **204** (for protocol processing), to Feature Processor Function **224** (for feature processing), and to Connection Manager **206** (for connection

control). Call Segment Instance Service **202** corresponds to the AIN 1.0 Call Segment (CS) object.

Call Segment Instance Service **202** is provided via a Call Segment Instance **306** that is specifically associated with a particular active facility at a particular call state. Identical active facilities with different call states are considered different Call Segment Instances **306**.

Call Segment Instance Service **202** comprises two conceptual entities: Connection Point (CP) Conceptual Entity **412** and Segment Call-Half Manager Conceptual Entity **410**.

Connection Point (CP) Conceptual Entity **412** is the entity aware of the connectivity of connectors within a Call Segment Instance **306**. A CP **412** is a representation of connectors in some state of bearer connectivity (one-way, two-way, multi-way, etc.). Multiple CPs **412** within a call are not in a state of bearer connectivity, but may be either brought into connectivity by joining them. A CP **412** may be removed from a state of bearer connectivity by splitting it.

CP **412** maintains information relevant to the status of a call half's connectors; as such, no state machine is needed to provide that capability. A connector represents the connection between two (or more) connection points. A connector may be either an active connector or a passive connector. An active connector is any connector between a Call Segment Instance **306** and a Facility Instance **304**; a Call Segment Instance **306** can have only one active connector. A passive connector is any connector between two Call Segment Instances **306**. A CP can have a maximum of one active connector, but can have any number of passive connectors. However, a CP does not require an active connector; a CP may represent a connection of two passive connectors (for example, a call on hold with music). Since CPs are not required to have an active connector, there may be a situation where segments are not managing actual facilities, but are instead managing the connection between other segments. If a segment were placed in such a situation, it would represent and control the relationship between two end-point segments.

Segment Call-Half Manager Conceptual Entity **410** represents the call data processing within a segment. The primary aspect of Segment Call-Half Manager **410** is a Call State Machine, which is a finite state machine responsible for the execution of basic call processing. This object is the state machine typically associated with call processing within ITU standards.

3. The Facility Service

Facility Service **204** is a protocol state machine which provides all data processing related to the physical resources (i.e., facilities) involved in a call. Facility Service **204** processes raw signaling data provided by Switch Fabric Proxy Service **208**. The resulting actions describe detailed call progress changes that initiate abstract call progress changes (which are given to Call Segment Instance **306**). Information provided to Facility Service **204** by Switch Fabric Proxy Service **208** is usually formed of facility-related events (on-hook, off-hook, wink) and actual data received (DTMF digits, ISUP messages, Q.931 messages) from the facility. Switch Fabric Proxy Service **208** provides this information in an unprocessed form, allowing Facility Service **204** to process this data into abstract events for Call Segment Instance **306** (e.g., Call Setup Request, Call Disconnect Request, etc.).

Facility Service **204** also acts as a server to the Call Segment Instance Service **202**, fulfilling requests for facility manipulation. This manipulation is received as abstract requests (e.g., Provide Tone, Setup Request, Disconnect) and causes the facility to perform actions on the Switch Fabric Proxy Service to fulfill the manipulation requests. The majority of the APIs defined for Facility Service **204** that are pro-

vided to Call Segment Instance Service **202** are not protocol-specific. Rather, these requests are abstract interfaces that span all protocol families and yield protocol-specific actions based on logic contained entirely within Facility Service **204**.

Facility Service **204** comprises Facility Channel Conceptual Entity **414**, Signaling Channel Conceptual Entity **416**, and Bearer Channel Conceptual Entity **418**.

Facility Channel (FCH) Conceptual Entity **414** is a functional component which provides the ability to logically "bind" a bearer channel to its associated signaling. This binding happens on indication from the Signaling Channel that a Bearer Channel is required for the call.

Signaling Channel (SCH) Conceptual Entity **416** is the object that addresses all of those aspects of FCH **414** associated with communications with distant SF-NEs **112** and SI-NEs **110**. SCH **416** takes care of the signaling for a call half. It is minimally available in three flavors: SS7 ISUP, PRI, and inband. SCH **416** is where new types of signaling are implemented (for example, BTUP or R2).

Bearer Channel (BCH) Conceptual Entity **418** provides an association between a Call Segment Instance **306** and the set of physical devices associated with providing bearer services for that Call Segment Instance **306**. These physical devices include T1s, E1s, DS0s, and other bearer devices, but exclude any device strictly associated with signaling. This association permits invoking entities to refer to these devices in an abstract command structure, eliminating the need to refer to all devices within the association. There is one BCH **418** associated with each FCH **414**. However, BCH **418** may represent a group of circuits; for example, a 6x64 wideband call would have six circuits actually involved but would be represented as one BCH **418**.

4. The Connection Manager Service

Connection Manager Service **206** provides the ability to establish and track connections within an SF-NE **112**. Connection Manager Service **206** rationalizes abstract connection requests from Call Segment Instance Service **202** and resolves these requests into physical connection requests for Switch Fabric Function **222**. For example, Connection Manager Service **206** will receive a request to make a particular connection, and translate this request into a request to physically connect two particular ports. Connection Manager Service **206** will minimally receive connection instructions from each Call Segment Instance **306**, and will resolve these instructions into specific matrix actions for Switch Fabric Function **222** which connect the devices controlled by each segment. A very basic call will result in two segments which provide data to Connection Manager Service **206**, which then resolves this data into a single connection request to Switch Fabric Proxy Service **208**.

5. The Switch Fabric Proxy Service

Switch Fabric Proxy Service **208** provides all mechanisms to control Switch Fabric Function **222** bearer and connectivity resources. It is the fundamental aspect of Switch Fabric Service **112** that it provides clients, such as Call Segment Instance **306**, the ability to associate bearer resources and to request connectivity of resources.

Switch Fabric Proxy Service **208** provides IDNOS-compatible APIs **216** and **218** towards the remainder of call processing, and provides Switch Fabric-specific API **220** towards the actual switch fabric equipment (SF-NEs **112**). As such, Switch Fabric Proxy Service **208** acts as a gateway between the IDNOS client/server environment and the Switch Fabric-specific messaging environment. Switch Fabric Proxy Service **208** is required to be accessible through the IDNOS RPC execution support capability, whereas SF-NEs **112** are not required to be accessible through the IDNOS

RPC. It is acceptable to have the Switch Fabric Proxy Service **208** built within an SF-NE **112**, but such a configuration would require an IDNOS-compliant physical interface between the SF-NE **112** and communicating SI-NEs **110**.

Switch Fabric Proxy Service **208** provides interfaces to the call processing clients that deal with device connectivity, signaling, etc. These interfaces (also called “agents”) are grouped into the conceptual entities described below.

Signal Protocol Manager (SPM) Conceptual Entity **422** is a distributor of signaling information to the various Signaling Channels which process such information. SPM **422** is capable of rudimentary processing of signaling information and may combine multiple events into a single Signaling Channel indication (under the guidance of Signaling Channel **416**).

Matrix Conceptual Entity **420** is the functional component responsible for interconnection of compatible bearer channels, enabling the transfer of information between bearer channels on facilities external to SF-NE **112**. Matrix **420** performs its functions under the control of Connection Manager **419** within SI-NE **112**.

External Device Conceptual Entity **424** is the functional component that comprises all physical interfaces external to SF-NE **112**. These external interfaces may provide bearer transport, data transport, or a mixture of bearer and data transport. External Device Conceptual Entity **424** also encompasses those devices that provide service circuit-typed capabilities (receivers, voice recognizers, etc.).

OAM&P Manager Conceptual Entity **428** is the functional component that handles the operation, administration, maintenance, and provisioning functions for an SI-NE **110** and an SF-NE **112**. This functionality is distributed between the SI-NE **110** and SF-NE **112**.

Resource Manager Conceptual Entity **426** is the object responsible for maintaining a distributed view of the current availability of resources throughout a Switch Node **200**, including all resources that directly apply to a Switch Intelligence Function **226**.

Device Pool Conceptual Entity **430** represents all available external devices that may be attached to Facility Channel **414** as External Devices **424** for purposes of signaling or bearer service.

B. API Interfaces

In a preferred embodiment of the present invention, many of the interfaces are implemented as application programming interfaces (APIs). As will be apparent to one skilled in the relevant arts, other interface implementations may be employed without departing from the spirit and scope of the present invention.

The capability to customize Switch Intelligence Function **226** is a hallmark of the present invention. In a preferred embodiment of the present invention, Call Segment Instance Service **202** and Facilities Service **204** are independently customizable. Thus, according to a preferred embodiment of the present invention, Call Segment Instance Service **202** and Facilities Service **204** each provide two types of APIs: programming APIs and control APIs. FIG. **5** is an object view of Call Segment Instance Service **202**, and is useful in explaining the difference between these two types of APIs. As will be apparent to one skilled in the relevant art, this discussion [is] applies in a similar fashion to Facilities Service **204**.

A significant advantage of the provision of standard control APIs is that Call Segment Instance Service **202**, Facilities Service **204**, Connection Manager Service **206**, and Switch Fabric Proxy Service **208** may each be provided by different vendors.

1. Programming (Non-Instance) APIs

In FIG. **5**, Call Segment Instance Service **202** is depicted as being comprised of two environments: Offline Environment **506** and Runtime Environment **504**. Offline Environment **506**

is accessed by Call Model Creation Environment **502** via call Model Definition Language (CMDL) Toolkit API **414**. CMDL Toolkit API **414** is a programming (non-instance) API. Facility Service **204** has a similar toolkit interface. Call Model Creation Environment **502** is based on the service creation environment concept. Facility Service **204** has a similar service creation environment.

These API interfaces permit element behaviors to be redefined to facilitate the creation of new services, either within the switching system or within an associated feature engine. CMDL Toolkit API **414** can be employed to create class definitions for aspects of the call model, such as Call State Machines **512**, prior to runtime. For example, these class definitions may include a Call State Machine **512A** for AIN 1.0, a Call State Machine **512B** for ITU CS-1, and a Call State Machine **512C** for an MCI call state machine. Call Segment Instance Service **202** creates instances **508** of the defined call state machines, and maintains call data instances **510** in response to requests from Feature Processor Function **224** received via control APIs **210**, **212**, and **214**. The programming API for Facility Service **204** can be employed in a similar fashion, for example, to create a Signaling State Machine.

Call Model Creation Environment **502** provides a CMDL Library **514** of the states, events, and atomics which make up the CMDL. In a state machine, an atomic is a non-controlling single step action (for example, a procedure call). An event is a notification to the Switch Fabric Function of activity.

2. Control (Instance) APIs

In operation, the Runtime Environment **504** of Call Segment Instance Service **202** interacts with Feature Processor Function **224**, Connection Manager Service **206**, and Facility Service **204** via control APIs **210**, **212**, and **214**, respectively, to perform call processing. Call Segment Instance Service **202** instantiates (i.e., creates), for example, Call State Machine Instances **508** and Call Data Instances **510** in response to requests for service.

Because Connection Manager Service **206** and Facility Service **204** provide standard control APIs, the provider of Switch Intelligence Function **226** has the ability to “mix and match” components within the Switch Intelligence Function, allowing a “buy/build” decision on a case by case basis.

III. An Example: Three-Way Call

As an example of the operation of the present invention according to a preferred embodiment, consider a three-way call, which is a specific type of a conference call. This example will be described with reference to FIG. **3**. The three way call is a feature which has been created for, and is running on, a Feature Processor **114**.

A three-way call is placed via an External Function **228** having both bearer and signaling components (e.g., a LEC or PBX). In response, the signaling component of External Function **228** provides a signaling request to Switch Fabric Function **222**, which maps the request to Switch Intelligence Function **226**. Facility Service **204** performs certain signaling processing (performing early address determination, unpacking various protocols into a common protocol, parsing of the common protocol) and passes the event to Call Segment Instance Service **202**, which instantiates a Call Segment Instance **306A**, including a Call State Machine Instance **508**, to represent call half **320A**.

Call Segment Instance Service **202** informs Connection Manager **206** of the status of Active Connector **308A** and any Passive Connectors **310** (there are none yet, as Party A is still the only party to the call). In response, Connection Manager

Service 206 directs Switch Fabric Function 222 (via Switch Fabric Proxy Service 208) to make the required physical connections.

Because Party A is requesting a feature (the three-way call), Call Segment Instance Service 202 triggers Feature Processor Function 224. In response, Feature Processor Function 224 provides a command, via API 210, to Call Segment Instance Service 202, to add Parties B and C to the call. In response, Call Segment Instance Service 202 instantiates Call Segment Instances 306B and 306C, instructs Facility Service 204 to instantiate Facility Instances 304B and 304C, and instructs Connection Manager Service 206 to create Passive Connectors 310A and 310B and Active Connectors 308B and 308C. Connection Manager Service 206 directs Switch Fabric Function 222 (via Switch Fabric Proxy Service 208) to make the necessary physical connections, thus creating the three-way call.

IV. Conclusion

While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Thus the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

1. An apparatus for decentralizing communication services in a telecommunications system, comprising:

[a switch fabric which provides bearer functions;]

a switch intelligence which provides control functions for [said] a switch fabric, said switch intelligence being logically separated from said switch fabric and being implemented in a separate network element from said switch fabric, the switch intelligence being configured to:

process information received from the switch fabric, the information comprising a facility related event associated with a call,

maintain a call state associated with completing the call in accordance with a call model, the call model indicating how the information will be processed,

identify at least one point in call associated with completing the call, and

forward a request for a telecommunications function in response to the identified at least one point in call;

a switch fabric proxy service for providing a normalized interface between said switch fabric and said switch intelligence for [all] communications involving said switch fabric [by interfacing to said switch fabric with any one of a plurality of application program interfaces] and interfacing to said switch intelligence with a uniform application program interface, wherein the normalized interface comprises any one of a plurality of vendor-specific interfaces associated with the switch fabric; and

a feature processor, said feature processor configured to: receive the request for the telecommunications function, and

[executing at least one] execute the telecommunications function[, for interacting with said switch intelligence to thereby provide said telecommunications feature] in response to the received request.

2. The [system] apparatus of claim 1, wherein said switch intelligence [further] comprises:

[at least one facility instance instantiated by a] facility service [using a facility model, said facility instance representing the] logic configured to represent bearer and signaling facilities of a party to [a] the call, for interacting with said switch fabric proxy service to communicate with said switch fabric, the facility service logic configured to receive the facility related event and perform protocol processing on the information received from the switch fabric, wherein the facility related event comprises at least one of an off-hook indication, an on-hook indication or a wink.

3. The [system] apparatus of claim 2, wherein said switch intelligence further comprises:

[a] connection manager [service representing the connectors for said party to a call for interacting with said switch fabric proxy service to communicate with said switch fabric] logic configured to forward connection information to the switch fabric, the connection information instructing the switch to establish physical connections to complete the call.

4. The [system] apparatus of claim [3] 1, wherein said switch intelligence [further] comprises:

[at least one call segment instance instantiated by a] call segment [instance service] logic configured to: represent a status of at least two call halves associated with completing the call in accordance with the call model, and

[using a call model, said call segment instance representing the call logic and call data for said party to a call, for interacting with said feature processor, said connection manager service, and said facility instance] perform call processing for each of the at least two call halves.

5. The [system] apparatus of claim [2] 1, wherein said switch intelligence [further] comprises:

a [first] call processing creation environment, said [first] call processing creation environment interacting with said [facility service,] switch intelligence for modifying said [facility] call model without modifying the switch fabric.

6. The [system] apparatus of claim 4, wherein said switch intelligence further comprises:

a [second] call processing creation environment, said [second] call processing creation environment interacting with said call segment [instance service] logic, for modifying said call model.

7. The [system] apparatus of claim 2, wherein said switch intelligence further comprises:

a [third] call processing creation environment, said [third] call processing creation environment interacting with said facility service[,] logic for creating new facility models.

8. The [system] apparatus of claim 4, wherein said switch intelligence further comprises:

a [fourth] call processing creation environment, said [fourth] call processing creation environment interacting with said call segment [instance service] logic, for creating new call models.

9. An apparatus comprising:

a switch-fabric proxy service for providing a normalized interface between a switch fabric and a switch intelligence for communications involving said switch fabric by interfacing to said switch fabric with any one of a plurality of application programming interfaces, wherein the switch fabric and the switch intelligence are implemented in separate network elements; and the switch intelligence, the switch intelligence being configured to:

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- receive notification of a facility related event associated with a call from the switch fabric, wherein the facility related event is received from the switch fabric as raw or unprocessed data which is associated with user activity at a telephone device,
perform call processing in accordance with a call model and in response to the notification,
maintain a status of at least two call halves associated with completing the call in accordance with the call model, and
direct the switch fabric to make physical connections for each of the at least two call halves to complete the call.
10. An apparatus according to claim 9, wherein said plurality of application programming interfaces is at least one of vendor-specific or switch-fabric-specific.
11. An apparatus comprising:
switch intelligence configured to:
receive notification of a facility related event associated with a call from a switch fabric, wherein the switch intelligence is implemented in a separate network element from a network element implementing the switch fabric and the facility related event is received from the switch fabric as raw or unprocessed data which is associated with user activity at a telephone device,
execute a call state machine, the call state machine being responsive to the notification of the facility related event and representing processing of the call as at least one call segment, wherein the at least one call segment corresponds to a call half,
provide an association between the at least one call segment and at least one physical device associated with completing the call, and
provide connection information to the switch fabric based on the association.
12. An apparatus according to claim 11, wherein said network element implementing the switch intelligence is physically separated from said network element implementing the switch fabric and is coupled to the network element implementing the switch fabric via a communications network.
13. An apparatus according to claim 11, wherein the network element implementing said switch intelligence is logically separated from the network element implementing said switch fabric.
14. An apparatus according to claim 11, further comprising:
a switch-fabric proxy service for providing a normalized interface between said switch fabric and the switch intelligence for communications involving said switch fabric, wherein said switch-fabric proxy service interfaces to said switch fabric with any one of a plurality of application programming interfaces and interfaces to said switch intelligence with a uniform application programming interface.
15. An apparatus according to claim 14 wherein each of said plurality of application programming interfaces comprises at least one of a vendor-specific application programming interface or a switch-fabric-specific application programming interface.
16. An apparatus according to claim 11, further comprising:
a switch-fabric proxy service for providing a normalized interface between said switch fabric and the switch intelligence for communications involving said switch fab-

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- ric, wherein said switch-fabric proxy service translates switch-fabric communications into switch-intelligence communications.
17. An apparatus according to claim 16 wherein said switch-fabric communications are at least one of vendor-specific or switch-fabric-specific.
18. An apparatus according to claim 11, further comprising:
a switch-fabric proxy service for providing a normalized interface between said switch fabric and the switch intelligence for communications involving said switch fabric, wherein said switch-fabric proxy service translates switch-intelligence communications into switch-fabric communications.
19. An apparatus according to claim 18, wherein said switch-fabric communications are at least one of vendor-specific or switch-fabric-specific.
20. An apparatus according to claim 11, further comprising:
a switch-fabric proxy service for providing a normalized interface between said switch fabric and the switch intelligence for communications involving said switch fabric, wherein said switch-fabric proxy service translates switch-fabric communications into communications defined according to a uniform interface.
21. An apparatus according to claim 11, further comprising:
a switch-fabric proxy service for providing a normalized interface between said switch fabric and a switch intelligence for communications involving said switch fabric, wherein said switch-fabric proxy service translates communications defined according to a uniform interface into switch-fabric communications.
22. The apparatus of claim 11, wherein the facility related event comprises at least one of on-hook, off-hook or wink.
23. An apparatus comprising:
a switch intelligence for providing control functions to at least one switch fabric and being implemented in a network element separate from the at least one switch fabric, the switch intelligence comprising:
processing logic configured to:
receive information from the at least one switch fabric, the information including a facility related event associated with a call, wherein the facility related event is received from the at least one switch fabric as raw or unprocessed data which is associated with user activity at a telephone device,
process the received information,
maintain call states in accordance with a call model for at least one party involved in the call, and
provide connection information to the at least one switch fabric for completing the call.
24. An apparatus according to claim 23 wherein said switch intelligence is one of logically separated or physically separated from said at least one switch fabric, the processing logic being further configured to:
identify at least one point in the call where a telecommunications function is required, and
send a request for the telecommunications function to a processor in response to the identified at least one point in the call.
25. An apparatus according to claim 24, further comprising:
a processor executing the telecommunications function in response to the request.
26. An apparatus according to claim 23, further comprising:

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a switch fabric proxy for providing a plurality of application programming interfaces for communications between the at least one switch fabric and the switch intelligence, wherein each of said plurality of application programming interfaces comprises at least one of a vendor-specific application programming interface or a switch-fabric-specific application programming interface.

27. An apparatus according to claim 23 wherein said switch intelligence provides control functions to a plurality of switch fabrics.

28. An apparatus according to claim 23 wherein said switch intelligence further comprises at least one of a facility service, a call connection manager service, or a call segment instance service.

29. An apparatus according to claim 28 wherein said at least one of a facility service, a call connection manager service, or a call segment instance service comprises a call segment instance service, the call segment instance service configured to maintain the call states for the at least one party involved in the call.

30. The apparatus of claim 23, wherein the facility related event comprises at least one of on-hook, off-hook or wink.

31. An apparatus, comprising:
means for receiving switch-fabric communications from a switch-fabric the means for receiving being implemented in a network element separate from the switch-fabric, and the switch-fabric communications including a facility related event associated with a call, wherein the facility related event is received from the switch-fabric as raw or unprocessed data which is associated with user activity at a telephone device;

means for processing the switch-fabric communications, wherein the means for processing is configured to maintain call states in accordance with a call model for at least one party involved in the call and generate connection information for completing the call; and

means for translating the connection information into switch-fabric communications for use by a switch fabric.

32. An apparatus, comprising:
means for translating switch-fabric communications into communications defined according to a uniform switch-intelligence interface, the means for translating being implemented in a network separate from a switch-fabric;

means for processing the switch-fabric communications comprising facility related event information associated with a call, wherein the facility related event is received from the switch-fabric as raw or unprocessed data which is associated with user activity at a telephone device, the means for processing being configured to:

maintain call states for at least one party involved in the call in accordance with a call model, and

execute the call model to generate connection information for completing the call; and

means for translating the communications defined according to the uniform switch-intelligence interface into switch-fabric communications.

33. The apparatus according to claim 32, further comprising:

means for translating communications defined according to the uniform interface into switch-intelligence communications; and

means for translating switch-intelligence communications into communications defined according to a uniform interface.

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34. An apparatus comprising:

a switch-fabric proxy service that is capable of at least one of translating switch-fabric communications into switch-intelligence communications, translating the switch-intelligence communications into the switch-fabric communications, translating the switch-fabric communications into communications defined according to a uniform switch-intelligence interface, or translating the communications defined according to a uniform switch-intelligence interface into the switch-fabric communications; and

a switch intelligence implemented in at least one network element, the at least one network element being a separate network element from a network element implementing a switch-fabric that is coupled to the switch-fabric proxy service, the switch intelligence being configured to:

receive notification of a facility related event associated with a call from a switch-fabric, wherein the facility related event is received from the switch-fabric as raw or unprocessed data which is associated with user activity at a telephone device,

execute a call model to generate connection information for completing the call in response to the notification, maintain call states for at least one party involved in the call in accordance with the call model, and

forward the connection information to the switch-fabric via the switch-fabric proxy service.

35. An apparatus according to claim 34, wherein said switch-fabric proxy service includes a normalized interface between the switch fabric and the switch intelligence.

36. The apparatus according to claim 34, wherein said at least one network element implementing the switch intelligence is one of logically separated or physically separated from the network element implementing the switch fabric and is coupled to the network element implementing the switch fabric via a communications network.

37. An apparatus according to claim 34, wherein the switch fabric includes said switch-fabric proxy service.

38. An apparatus according to claim 34, wherein the switch intelligence is further configured to:

maintain the call model, the call model affecting how calls received by the switch fabric will be processed and wherein the call model is modifiable at the switch intelligence without modifying the switch fabric.

39. An apparatus according to claim 34, wherein said switch-fabric proxy service includes an application programming interface for interfacing with the switch fabric.

40. An apparatus according to claim 37, wherein said application programming interface is at least one of a vendor-specific interface or a switch-fabric-specific interface.

41. An apparatus according to claim 34, wherein said switch-fabric proxy service includes an application programming interface for interfacing with the switch-intelligence.

42. An apparatus comprising:

a switch intelligence network element for controlling a switch fabric network element, the switch intelligence network element being implemented in a network element separate from the switch fabric network element and wherein said switch intelligence network element comprises:

processing logic configured to:

receive notification information comprising a facility related event associated with a call from the switch fabric network element, wherein the facility related event is received from the switch fabric network

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element as raw or unprocessed data which is associated with user activity at a telephone device, and perform call half processing for at least one party associated with the call in response to the notification information and in accordance with a call model.

43. An apparatus according to claim 42, wherein said processing logic is further configured to:

perform the call half processing in accordance with a call model, the call model representing at least one of an Advanced Intelligent Network (AIN) call model, an International Telecommunications Union (ITU) call model or a call model created by a service provider.

44. The apparatus according to claim 42, wherein said switch intelligence network element includes at least one of a first application programming interface communicable with a switch-fabric proxy service or a second application programming interface communicable with a feature processor that executes at least one telecommunications function.

45. The apparatus according to claim 42, further comprising at least one application programming interface communicable between at least one of a facility service, a call connection manager service, or a call segment instance service and another of said at least one of a facility service, a call connection manager service, or a call segment instance service.

46. An apparatus comprising:

a feature processor for executing at least one telecommunications function; and
switch intelligence configured to:

receive facility related event data associated with a call from a switch fabric, wherein the facility related event is received from the switch fabric as raw or unprocessed data which is associated with user activity at a telephone device,

perform call half processing associated with at least one party to the call in response to the facility related event data and in accordance with a call model, and provide connection information to an entity that received the call, wherein the connection information identifies physical connections to complete the call, wherein the switch intelligence is implemented in at least one network element, the at least one network element being a separate network element from the entity that received the call.

47. A non-transitory apparatus for controlling a switch fabric, the apparatus being implemented in at least one network element, the at least one network element being separate from the switch fabric, the apparatus comprising:

logic for processing a facility related event received from the switch fabric in accordance with a call model, wherein the facility related event is received from the switch fabric as raw or unprocessed data which is associated with user activity at a telephone device,

logic for performing call half processing for at least one party involved in the call in response to the facility related event and in accordance with the call model, and logic for forwarding connection information to the at least one switch fabric.

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48. The apparatus of claim 47, further comprising: interface logic including a first interface for communications between the apparatus and the switch fabric.

49. An apparatus, comprising:

a call completion device for providing bearer functions, said call completion device performing communications with a switch intelligence that is implemented in a separate network element from said call completion device, wherein the call completion device comprises a switch fabric, the call completion device being configured to:

forward a facility related event associated with a call to the switch intelligence, wherein the facility related event is received from the call completion device as raw or unprocessed data which is associated with user activity at a telephone device, and

receive bearer connection information from the switch intelligence in accordance with a call model executed by the switch intelligence.

50. The apparatus of claim 49, wherein the switch intelligence comprises a call state model, and wherein the call completion device communicates with the switch intelligence to affect a call state.

51. The apparatus of claim 50, wherein the call state is represented in the call state model.

52. The apparatus of claim 49, further comprising:

a switch fabric proxy service for providing an application programming interface for communications between the call completion device and the switch intelligence.

53. A non-transitory apparatus, comprising:

logic configured to receive information from a switch fabric that received a request for making a call, the logic being implemented in a network element separate from the switch fabric, the information comprising a facility related event, wherein the facility related event is received from the switch fabric as raw or unprocessed data which is associated with user activity at a telephone device;

logic configured to perform call half processing for at least a first party or a second party associated with the call in response to the facility related event and in accordance with a call model;

logic configured to generate connection information for the entity that received the request; and

logic configured to forward the connection information to the entity that received the request.

54. The apparatus of claim 53, wherein the apparatus is implemented in a network element that is separate from the entity that received the request.

55. The apparatus of claim 53, wherein the logic configured to perform call half processing maintains call states associated with completing the call in accordance with a call model.

56. The apparatus of claim 31, wherein the facility related event comprises at least one of on-hook, off-hook or wink.

57. The apparatus of claim 42, wherein the facility related event comprises at least one of on-hook, off-hook or wink.

58. The apparatus of claim 47, wherein the facility related event comprises at least one of on-hook, off-hook or wink.

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