A Model For Network and Telecommunication Global Service Convergence

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Abstract

Bearer service convergence between networks and telecommunication is briefly described in order to introduce the more general problem of service convergence. The technical environment required for such a convergence is analyzed, first from the stake holders point of view, then from the functional architecture point of view for the control plane and the signaling mechanisms.

1) Introduction: Services of a different kind

Engineers presently inherit two very different paradigms for the implementation of services by means of networks.

The "Telecommunication" paradigm used in telecommunication networks is characterized by a small number of services, usually of a peer to peer and persistent nature. Telecommunication services are based on complex functions offered by the telecom networks, with very little modification possibilities so that profiling and customization of services is extremely difficult to achieve. These services are usually offered only by the network operators, are charged on the basis of usage time and are executed on the proprietary software environment of the switch manufacturers.

This paradigm would not have been challenged if personal computing promoting the client-server architecture had not definitely established itself. From then the word "network" became synonymous to "computer network" with a service paradigm differing radically from the telecom paradigm. Indeed the telecom paradigm, with its constant bit rate, real time, peer to peer characteristics was not adapted in any way to the communication requirements of computers (highly bursty bit rate, best effort transactions, client-server mode of operation). A new paradigm emerged : the "network paradigm" used by the internet and characterized by non persistent client-server types of services, executed in private servers outside the network and requiring only elementary and simple functions from the network, usually connectionless functions. In this new paradigm, services are varied and rich in features and they are offered competitively by private service operators, independently from the network operators.

This opposition between both paradigms becomes significant when considering a "telecommunication-network convergence", a concept meaning that a single transfer capability (a unified network) is considered for offering both types of services : Telecom services and network services.

Several types of approaches have been considered for such a convergence.

The first type of approach consists in using one of the paradigms and modifying it to introduce the services belonging to the other paradigm. This type of approach may be done in two ways:

A first proposal consists in using the telecommunication network as a base and improving it to introduce the network services. This is the Integrated Service Digital Network (ISDN) proposal or Telecommunication proposal.

A symmetrical proposal consists in using the Internet as a base and improving its capabilities to introduce the telecom services. This is the Multimedia or Network proposal.

Indeed these two competing proposals fail to gain wide acceptance because it is not really more appropriate to introduce non persistent client server services, not requiring any connection or any control plane, on a telecom network than it is appropriate to introduce persistent, peer to peer, real time services requiring a control plane in a connection-less, best effort and statistically multiplexed network.

A second type of approach seems today more realistic, which consists in the creation of a new Next Generation Network (NGN) specifically designed to insure service compatibility. Is it however enough to base this NGN on a packet transfer mode with QOS mechanisms, i.e. to create a Converged Bearer Service to insure Global Service Convergence? We intend in this paper to demonstrate that Bearer Service Convergence and Bearer QOS mechanisms are not enough to insure global service convergence and that a new Service model has to be promoted. We will outline some bases for such a new "SIgnaling Model for Programmable Services On Networks" (SIMPSON) and we will use this model to show how various services and network functions may be made truly separated, independent and compatible. In doing so this paper will reflect the research effort presently undertaken by the ASTRONEFS group (Active Signaling and TRansport in an Open Network Environment for Future Services) [1].

2) Bearer and Service convergence

2.1) Bearer services convergence

A first necessary step towards global service convergence is the achievement of a transfer system able to carry different flow types with the requested QOS : Constant Bit Rate (CBR) flows with real time constraints (such as telephone traffic), CBR flows with less real time constraints (Video On Demand : VOD, file transfer), Best Effort flows (mail, transactional). The two first flow types demand a kind of connection oriented type of service (we will define further what we mean by the concept of connection). On the contrary the third type of flow demands the statistical gain of packet networks and the universal user interface provided by the TCP/IP protocols. NGN will therefore be transporting IP packets, some of them in a purely connection-less mode, some others within reserved virtual pipes implementing in this manner connection mechanisms. We will just quote here these mechanisms that have been already widely described elsewhere [2]. Three main mechanisms are proposed to reach this Bearer Service Convergence : Intserv, frequently associated with RSVP signaling is used to reserve the bandwidth requested for each flow, Diffserv, which may be associated with the Common Open Policy Service (COPS) signaling, is used to specify for each aggregated flow its scheduling priority within the routers, MPLS (Multi Protocol Label Switching) is used to aggregate traffic flows that may be routed together.

2.2) From bearer convergence to service convergence

The just mentioned first convergence step is dedicated to the transfer function (Bearer service) part of the global service. This step has to be followed by an other research effort in order to grasp the global convergence problem. Indeed, next generation networks should allow all types of services : non persistent, persistent, client-server, peer to peer, provided by independent stake holders but based on Network Generic Functions (NGF). We will define further what is meant by persistent or non persistent service and we will see that persistent services necessarily require a control plane to be setup. Presently proposed control plane architectures, usually designed for a specific paradigm should be analyzed to outline the common underlying structures so that they may be generalized to fulfill the requirements of the global service convergence paradigm, and to identify its signaling requirements.

Examples of control architectures for the telecommunication service paradigm are the Intelligent Network Architecture, the Parlay Architecture, the Programmable Networks architecture. Examples of control architectures for the network paradigm are the H323 architecture, the SIP architecture, the Soft-switches with the H248 Megaco architecture.

3) Characterization of services

3.1) Services

A service is a help that a system (server) brings to people or software applications (client). A service fulfills a requirement and is characterized by constraints.

Some services are local, executed by a local server directly accessible by the client, some services are remote, which means that they are executed on a remote platform linked to the client by means of a network.

The service concept is a recursive concept, or multi-tier concept : a level "*n*" service may invoke in its turn for its function the help of an other level "*n+1*" becoming in its turn a client.

3.2) Client server versus peer to peer

It is important at this point to clarify the Client-Server mode of operation from the Peer to Peer mode of operation.

Client-Server is an asynchronous, non associated mode of operation. The Client is the application, and is the only one to take the initiative of a service query. A server always waits for queries and just answers. There is no association of contexts between the client and the server and they operate in an asynchronous manner. Interfaces between a client and a server are called

Application Programming Interfaces APIs. They represent the ways Clients (application) request the services of a server.

In the peer to peer mode or cooperative mode, there is a context sharing. Contexts of cooperating entities have to be "associated" to form a single global context for one service instance, and signaling has to be used to get in one location a global context information stored in an other location.

3.3) Persistent versus non persistent services

We define as a Persistent Service a service where the session does not terminate with user activity. In a persistent service, an open session remains open even when the users remain inactive for a long period of time. Memory spaces assigned to the session remain assigned, instance data remain memorized. Persistent Services require state rich mechanisms. They also require to be setup, modified and released by special queries.

Persistent services require new functions from the network in addition to the bearer service functions: additional network generic functions and a control plane should be provided for theses services. This is why the multimedia effort of implementing persistent services such as telephony or videoconferencing involves the definition of a "control plane", and signaling mechanisms between the control plane entities.

We define as "Control Plane" the set of entities responsible for the setup, modification and release of a persistent service instance.

We define as "signaling" the exchange of interface instance data between the associated contexts of peer to peer control entities cooperating in the setup, modification or release of a same persistent service instance. This paper intends to categorize control plane entities so that signaling flows and paths may be systematically identified.

4) Functional roles and SIMPSON model

4.1) Service levels in the SIMPSON model

When undertaking to create a *SIgnaling Model for Programmable Services On new generation Networks* (SIMPSON) five service levels are identified (see figure 1), leading to a 5-tier client server model for the setup of a persistent service session:

A "user" is using an application to make progress in the completion of some task. The application is the Client operated by a "Service Owner" It is the first tier in the model. The client (application) will invoke the services of a "server" to get service data or eventually to run part of the service logic. The server is the 2d tier in the model. In this client-server model, the client mostly dedicates itself to service profiling, including presentation activities and is viewed by the server as a "virtual client", the server executing a standard service logic. The server is homed on a "Service Provider" platform.

The service logic in this service provider platform is represented by a graph of service components or Generic Service Elements GSE. These service elements are supplied by servers operated by a Service (Components) Operator. Components servers constitute the 3d tier of the model.

Some components require Network Generic Functions NGF such as Call services, Virtual Private Network services, Routing services, Multicast services etc. These NGF are performed by the servers of a "Network operator". Examples of such Network operator platforms may be PDP (Policy Decision Points) for the NGN (Next Generation Network) or the soft-switches (call agents) for IP telephony. Network operator platforms constitute the 4th tier of the model.

Finally some of the NGF may require the setup of bearer capabilities with defined QOS parameters. They invoke for this purpose Bearer Functions executed by the equipments of Bearer Services Operators. Bearer Services Operators equipment constitute the 5th tier of the model. *We define as a "connection" a bearer service resource reservation such as a bandwidth reservation or a particular scheduling mode reservation.* The Bearer Service Level is therefore specialized in the setup, modification or release of connections.

4.2) Client-server APIs and peer to peer signaling protocols.

The SIMPSON model identifies two different types of interactions between control plane entities. Interacting entities may belong to the same service level and they operate in the peer to peer mode. On the contrary, they may appear in adjacent service levels, in which case they operate in the Client-server mode. The SIMPSON model shows the various APIs and the various Signaling protocols required in a control plane architecture.

As APIs we find that the client interacts with the server by means of a Service to Provider Interface SPI. Servers interact with the component provider by means of the Provider to Operator Interface POI.

A good example of POI interface is the Parlay API [4] by which a server may invoke the components provided by a service operator Parlay platform such as an Ericsson Jambala platform.

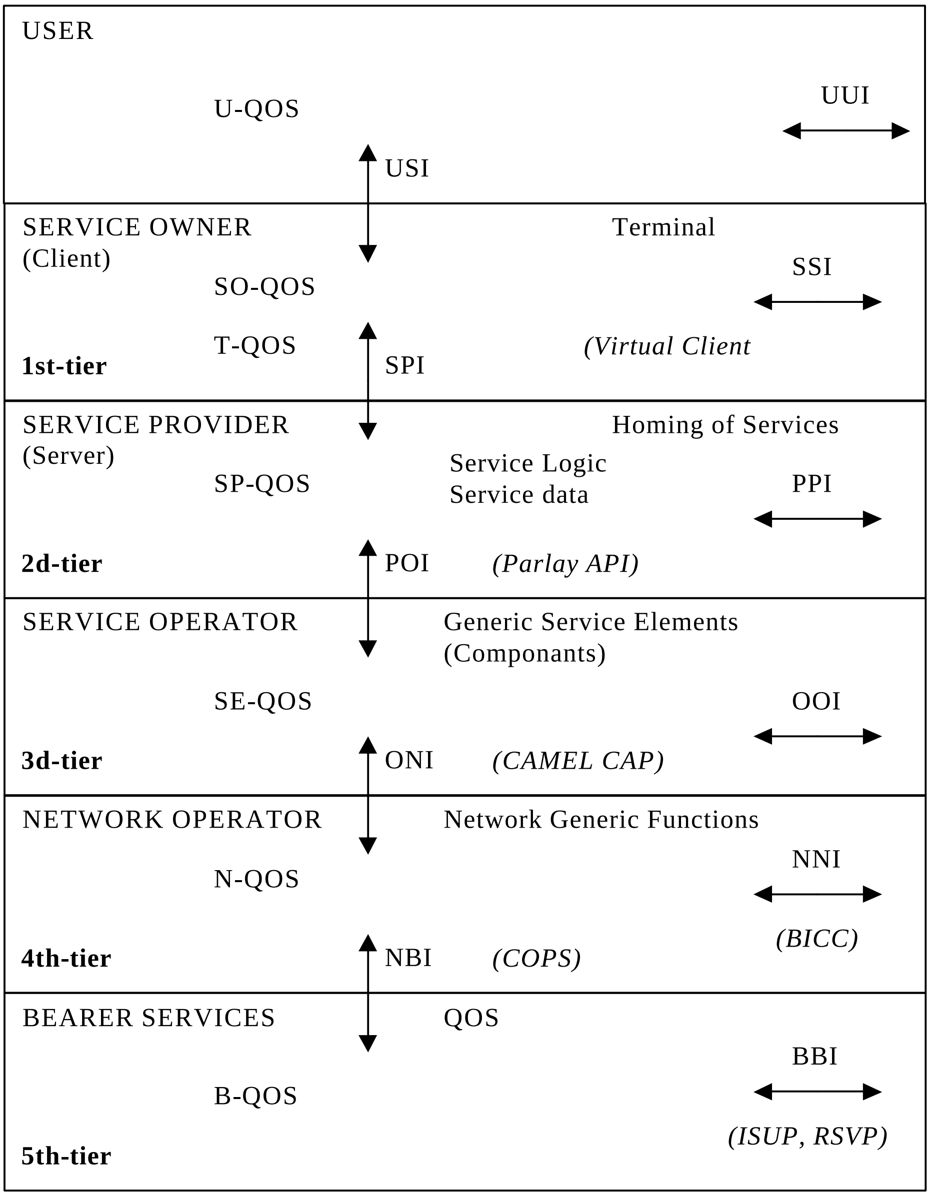

Figure 1 – Functional Roles in the SIMPSON model
(SIgnaling Model for Programmable Services On Networks)

Components request Network functions by means of the Operator to Network Interface ONI. An example of ONI could have been the intelligent network INAP set of operation, by which a Parlay platform may invoke the services of a Service Switching Point SSP control unit. However, INAP does not function as an API, INAP being a peer to peer signaling protocol involving context sharing as provided by the Transaction Capability TCAP protocol. We maintain however that despite this implementation discrepancy, a reengineered version of INAP could be viewed as an ONI type of API.

Network function request Bearer Services by means of the Network to Bearer Interface NBI. A good example of NBI are the H248 Megaco operations used by the soft-switches or the COPS operations used between the Policy Enforcement Points controlling routers and the Policy Decision Points PDP having a global view of connections.

As signaling protocols or peer to peer protocols we find in the first tier the Service to Service Interface SSI type of signaling between Clients.

We find in the second tier the Provider to Provider Interface PPI type of signaling between servers. We will see that a good example of the PPI type of signaling is given by the Mobile Application Part MAP signaling of the mobile networks.

We find in the third tier the service Operator to service Operator Interface OOI type of signaling between component providers. An example of OOI signaling is the SCP to SCP signaling of future IN capability sets, or the SCF to SDF and SCF to SRF signaling of IN-CS1.

We find in the fourth tier the Network to Network Interface NNI type of signaling between NGF. An example of NNI type of signaling is the Bearer Independent Call Control BICC signaling.

Finally, in the fifth tier we find the Bearer to Bearer Interface BBI type of signaling. Examples of BBI signaling abound due to fact that the Plain Old Telephone Service POTS is above all a connection control service. All Circuit Associated Signaling CAS protocols are actually BBI types of signaling protocols. The most important BBI signaling protocol at this point is the ISDN User Part ISUP signaling protocol widely used between telephone exchanges.

4.3) Various aspects of QOS

We define by *Quality of Service QOS the service properties that contribute to the level of satisfaction perceived by the service users*. QOS is measured by a number of parameters attached to these properties. From the SIMPSON model we derive that QOS may be classified into the following QOS levels :

User QOS (U-QOS) : or Subscription QOS. This the QOS negotiated by the user when subscribing the service. This is the QOS that must be maintained on the basis of the other classes of QOS defined further. This QOS is statically defined.

Service Owner QOS (SO-QOS) : defines the service requirements from the client application point of view. A range of acceptable QOS may be defined. The requirements depend on the service. This QOS is static in respect to the service. A subclass of the SO-QOS is the Terminal QOS (T-QOS) that gathers the terminal capabilities. A range of acceptable capabilities may be defined. These capabilities are static in respect to the terminal.

Service Provider QOS (SP-QOS) : defines the service requirements from the provider server point of view. A range of acceptable QOS may be defined. The requirements depend on the service. This QOS is static in respect to the service.

Service Elements QOS (SE-QOS) : defines the service requirements from the component server or service element server point of view. A range of acceptable QOS may be defined. The requirements depend on the service. This QOS is static in respect to the service.

Service Elements QOS (SE-QOS) : defines the service requirements from the component server or service element server point of view. A range of acceptable QOS may be defined. The requirements depend on the service. This QOS is static in respect to the service.

Network functions QOS (N-QOS) : defines the service requirements from the network functions point of view. A range of acceptable QOS may be defined. The requirements depend on the service. This QOS is static in respect to the network functions.

Bearer Capabilities QOS (B-QOS) : gathers all the parameters and mechanisms defining the underlying networks bearer capabilities. This is a dynamical QOS

4.4) The role of the signaling network. The SIMPSON model is a Programmable Network or Active Network model

We should point out here that the service levels outlined by the SIMPSON model are applications according to the definition of Open System Interconnection OSI model. All SIMPSON service levels are therefore layer seven applications. As shown in Figure 2, all types of signaling outlined by this model, either APIs between clients and servers in adjacent levels or peer to peer signaling between entities in the same level have to be transported by an underlying signaling network : *The control plane signaling network.* In other words, each line between levels in the model actually represent some exchange of information over a signaling network. This signaling network may be in-band, sharing the bandwidth of the user network and we will have user capsules with headers containing the signaling information. This approach is the *active signaling* approach. On the contrary signaling may be transported out-band in respect to user signals. This second approach is *the Programmable Network* approach.

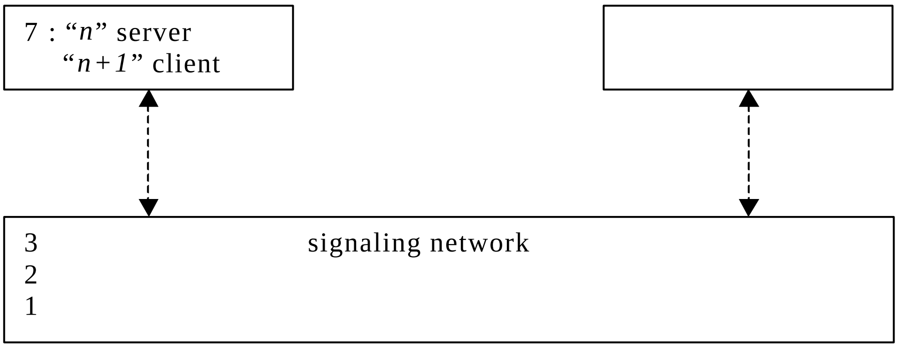

Figure 2 – SIMPSON service levels and the OSI model

4.5) The SIMPSON model is an unbundled model

Unbundling means that different roles may be executed by equipments belonging to different organizations, with the least co-localization of equipment as possible. This may be achieved if the functions in one role are completely independent of the functions in an other role, or just require minimum signaling in between. Unbundling is a desirable goal since the easiest way to create new services in one role is to have this role independent of the functions of the other roles. Because the SIMPSON model defines relationships between roles as different levels of client server interaction, and because the client server model has largely proven its independence between a client and a server, the different service levels of this model are clearly independent and choice functions for unbundling. However we will give further additional conditions, that we call the "precedence principle" that must be obeyed to insure total independence between roles.

5) Mapping classical services on the SIMPSON model.

5.1) Mapping a telecom service on the SIMPSON model: the telephone service

We describe here how the simple telephone service, with no features may be mapped, as shown in figure 3 on the SIMPSON model, with functions interacting in the client server mode. This is a theoretical model that could be implemented and would work. However present telephone exchanges do not exactly function in this manner, the functions described here being either implemented in a single process or interacting in the peer to peer mode (explaining the above mentioned INAP discrepancy).

Up to now, telephone terminals were simple equipments designed with a "minimum cost concern" in mind. The Client function (at the Service Owner level) was thus located at the Central Office CO as a "User Interaction" function. Actually, the CO control unit collocates together the Service Owner (client), Service Provider (server), the Service Operator (service elements), the Network Operator (network functions), and the Bearer services (connection control) functions. Such a centralization of functions at the central office control unit is explained by the global role that telecom operators used to have, a single organization taking care of all the roles.

The server part may be represented as "Originating Access", "Supervision" and Terminating Access" functions. The originating access function determines the subscription information and the authentication information about the originating subscriber and, if authentication is achieved, returns its "User Profile".
The terminating access function executes name address translation for the called party. For example, given an MSISDN number (name) of a called mobile telephone user, the terminating access function determines a roaming number MSRN (address) for this called party. Mobile networks use a database server called Home

Location Register HLR for this terminating access function. The supervision function is mainly in charge of supervising the "on-hook / off-hook" transitions of the involved parties and of deciding to release the service instance according to the telephone service paradigm explained further. These three Service Provider Services cooperate in a peer to peer manner to the same instance of global service execution. Their interactions are therefore a PPI type of signaling. In the case of Mobile Networks we know that this PPI signaling is the Mobile Application Part MAP signaling. The only Service Element used here would be the "charge function" mainly recording the answer time, the release time and the cost per second of service usage. The Network Generic Function used would be the "Routing Function" in charge of translating a called party number into a Route Index and a Charge Index.

The "Connect" function is the Bearer Service in this simple telephone case. It is really one of the most important functions of a call processing program, taking the route index as an input and executing trunk selection within the trunk group corresponding to the route and a path search within the switching fabric of the telephone exchange. We include in this "Connect" function, which has a hop by hop (link by link) nature, the BBI type of signaling (TUP or ISUP) to the next exchange so that this next exchange may in its turn establish the connection.

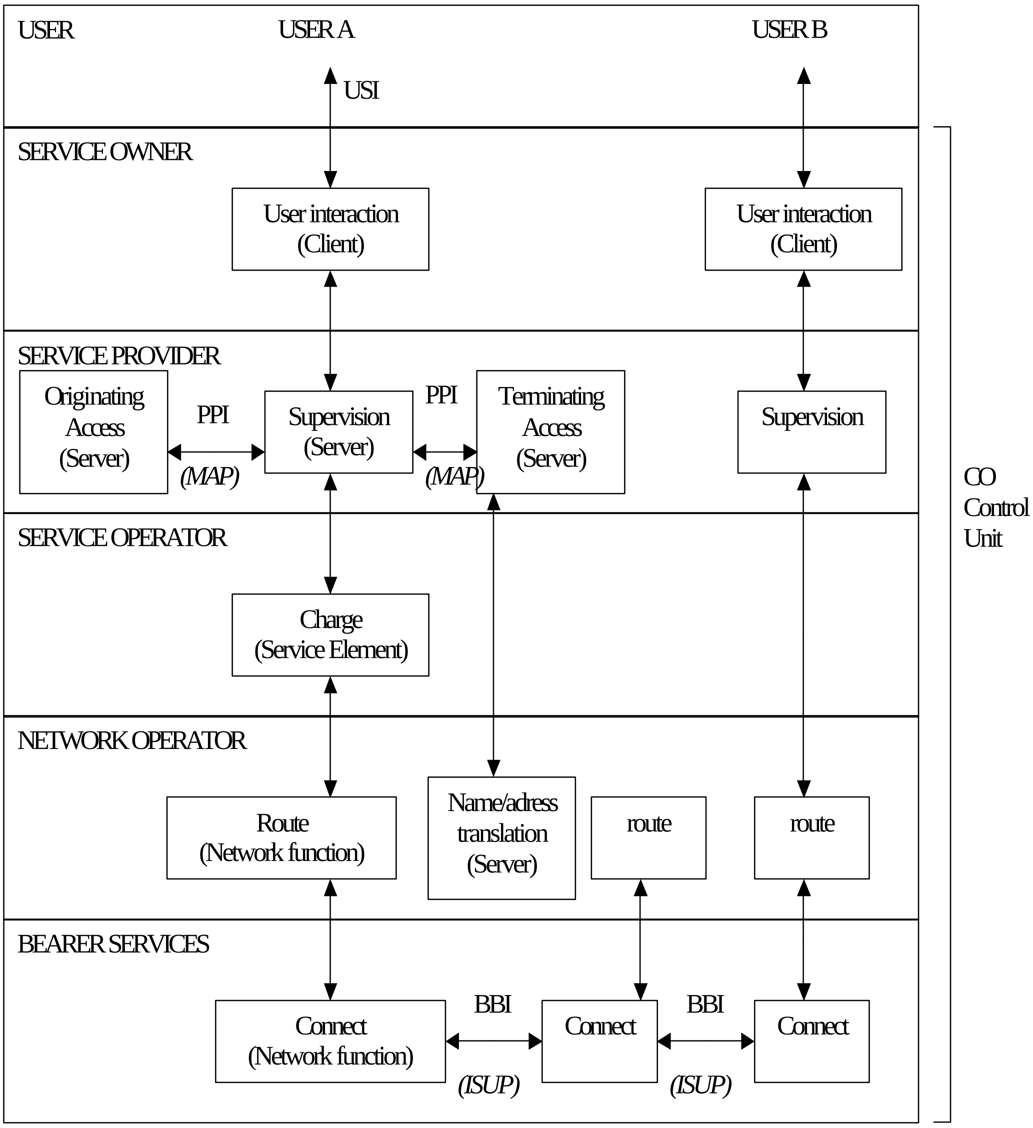

Figure 3 – SIMPSON view of a simple telephone service instance

5.2) Mapping a Network service on the SIMPSON model: the mail service

We now describe how a specific internet type of service may be mapped, as shown in figure 4 on the SIMPSON model, with functions interacting in the client server mode. In the case of internet service, terminals are sophisticated PCs or handheld types of PCs and they normally include the Service Owner level or client. For the mail service, this client is a mailer program.

The Service Provider level consists in a Simple Mail Transfer Protocol SMTP server usually homed by the Internet Service Provider.

At the network operator level, the SYN command establishes a call to the distant Mailbox server . Indeed, the TCP connection, which is not a connection in our definition (no transfer resources are reserved) is to be viewed as a "call" function belonging to the network generic functions. This call is established over a connectionless, best effort, connectionless capability requiring no special setup in the control plane.

It should be noted here that data exchanges between the entities of figures 3 and 4 are only signaling messages of the control plane. User plane data do not follow these paths. For most internet services, the user plane network termination is usually located in the user terminal.

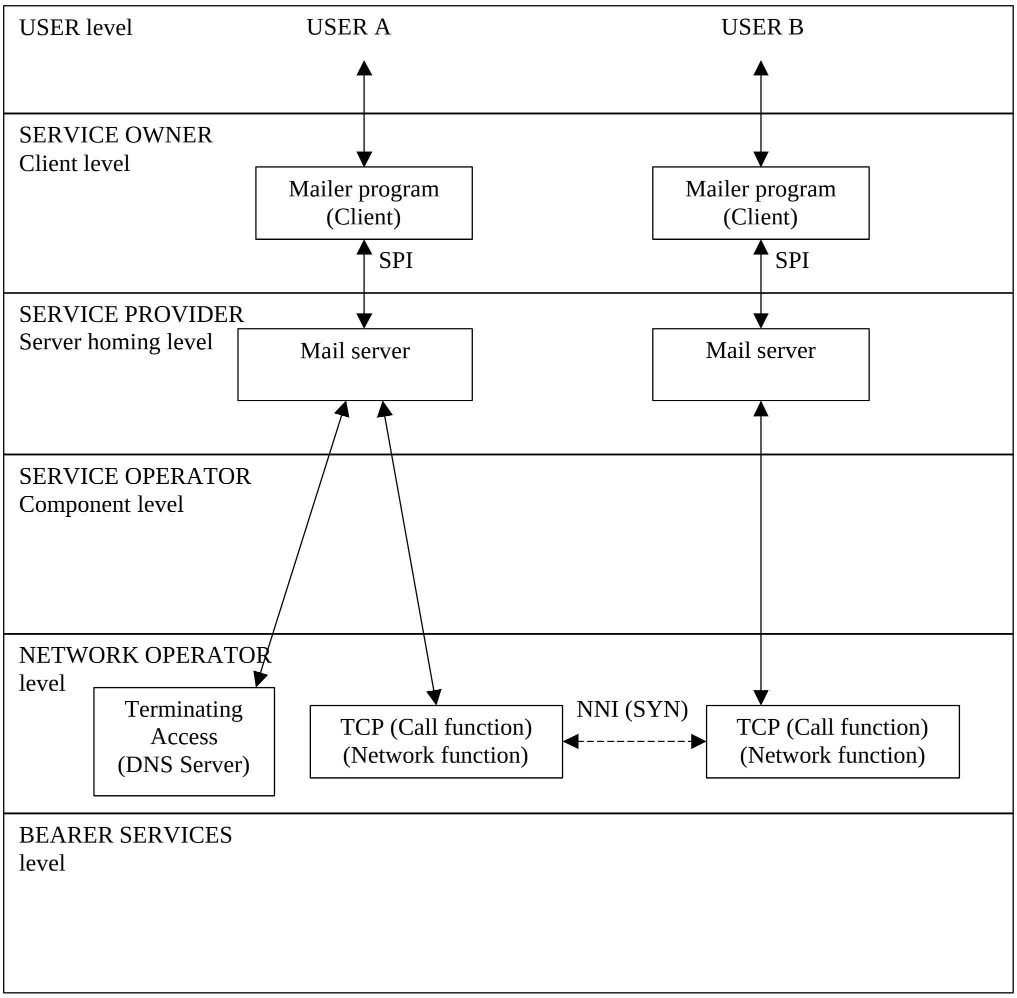

Figure 4 – An example of internet service : Mail Service

5.3) Mapping a Parlay service on the SIMPSON model

The Parlay group [4] proposes a new service architecture differing from the Intelligent Network IN architecture by a supplementary level of service customization. Rather than buying the standard service of some service operator, a given organization may request an adaptation of the operator's service to provide a version of the service customized to his special requirements. The service operator platform in this view becomes a server to the service provider client. Parlay defines an API between a service provider platform and the service operator platform.

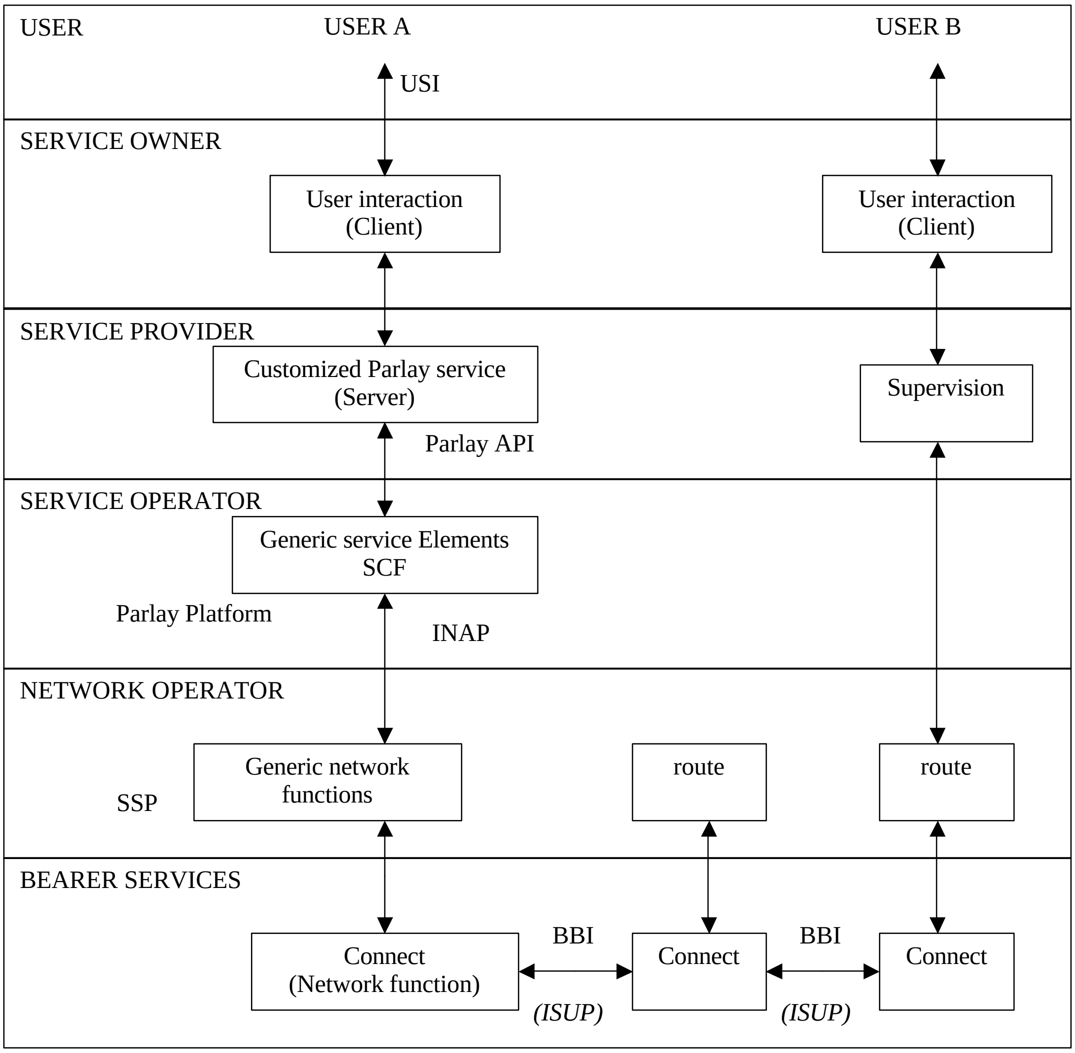

Figure 5 – SIMPSON view of a Parlay service

6) Generic Service elements

We define as *Intelligent Network IN service, a type of service that requires external operator information or network functions for its completion*. A service that could be fully executed from a terminal like a Weather Forecast service or a Stock Exchange service or any Web page information service, would not be an IN service. IN services are to be viewed as a script of service elements, some of the service elements requiring the execution of Generic Network Functions for their completion. For example, a call forwarding service with no “tromboning” effect would be an intelligent network service because only the network operator is in position to now where the called party is located.

It follows from its definition that an intelligent service is a sequence (also called a script) or a composition of Service Elements supplied by a the service operator, some of these service elements requiring network information or operations. Efficient Service Element composition is therefore an important research item. Several solutions have been used for the description of Service Elements. They range from the IN-CS1 Service Independent Building Block concept to the SIP CGI concept passing trough the CORBA component concept, the Enterprise Java Beans, etc.

7) Generic Network functions

7.1) Network invariant functions

The SIMPSON model considers that some functions can only be undertaken by the equipment of the network operator. Dynamic routing based on real time load information, intelligent routing avoiding the tromboning effect for forwarded parties, efficient multicast routing, name-network address conversion, establish a call, route connectionless, play announcements, apply charging, are just a few examples of such generic network functions. A service level containing functions that may be achieved only by the Network Operator is therefore required named Network operator level in the SIMPSON model. IEEE P1520 Proposed Standard for Application Programming Interfaces for Networks [3] calls this level the “Network Generic Service Level” defining the “L” (lower) interface as the API interface between the Simpson Network Operator level and the Simpson Bearer Level, and the “U” (upper) interface as the API between the Simpson Service Operator level and the Simpson Network operator level. The Simpson network operator level provides the upper layer a generic view of any broadband network, regardless of the actual implementation of this network.

7.2) The Call Control function

An important Network generic function is “Call Control”. To explain the “Call” concept we have to define the “association” concept first.

To each instance of a persistent service corresponds a context (or a memory space) in each platform participating into the service. These individual contexts together form a global context. However each individual part of the global context should have some index to the other parts in remote machines to be able to get information by means of signaling from these other memories. These indexes are called references and the two contexts are “associated” when each one has a reference for the other.

According to our definition, *a call is an association graph between contexts established at the network operator level for network end points*. This graph of association is persistent, which means that it remains established even in the lack of activity of users.

Persistent services require call setup. *The notion of call is an “end to end” notion*. It involves only the network operator contexts associated with the network end points. The notion of call is independent from the bearer service. A call may correspond to a path of connections or may just be established other a connectionless bearer service. The very important Transaction Capability TCAP protocol used for non circuit associated signaling over the SS7 signaling network is a nice example of a call service (association service) over a connectionless network.

7.3) The localization function

An other important Network generic function is the localization function. An origination always take place from a location hardware address : a MAC address in data networks, a line equipment number in a fixed telephone network, a base station identifier in a mobile network. It is important to know who is using this location i.e. to find the name of this location user. In the telephone network, this is the “originating translation” function that finds out the name (Directory number) attached to the address (line equipment number). More generally this is the localization function that updates the current location of a given user. This is a network generic function because it is network dependant.

8) Invariant services and signaling domains

8.1) Originating access service

We can remark at this point that the localization function is a part of a global service that we call the “Originating Access service” that involves functions at every service level of the SIMPSON model. We define that *the Originating Access Service is the acquisition of all the characteristics of a user that logs in a network.*

This requires functions at every level. At the service provider level: what is the subscription status of this user, which are the services he is entitled to, with which SP-QOS? At the service operator level this includes an authentication function. At the Network operator level this includes the localization function to update the location of the user in respect to the network.

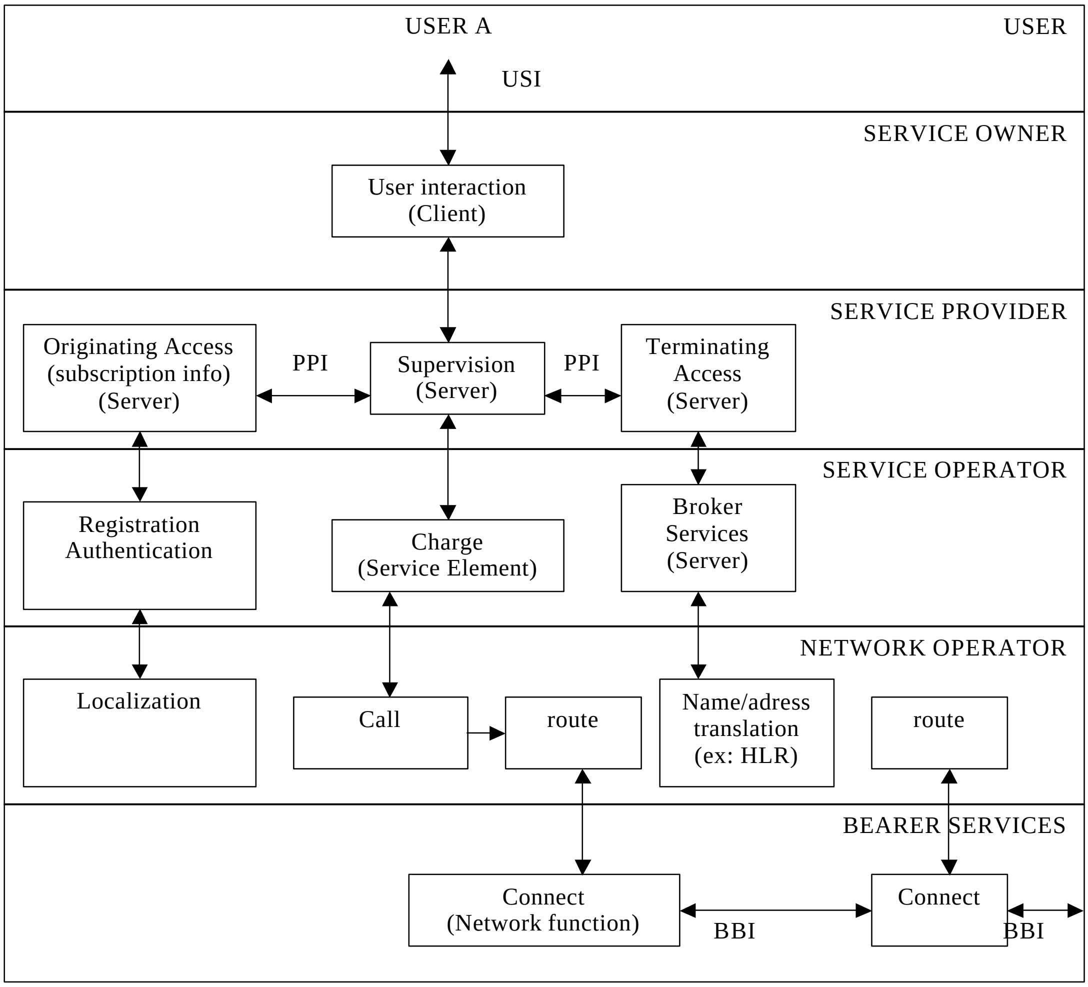

Figure 6 – SIMPSON view of a general service

8.2) Terminating access service

We define as *Terminating Access Service the name-address translation service for an entity that is to be joined to the service instance*. Again this is a global service that involves functions at every service level of the SIMPSON model. An entity may have a name in a service name space at the service operator level, a broker is typically a service operator function pointing to a server name for the entity, and finally a server name to network address translation such as the DNS service finds out the network address for the entity.

8.3) A general service model

Globally a service may be viewed as the composition of an originating access service, the service per-se, as many terminating access services as joined parties, and eventual call functions for persistent services. Figure 6 shows a general example of a global service composition.

8.4) Signaling Domains

This general service decomposition identifies *Signaling Domains* : *The Access Signaling Domains* for all signaling with originating and terminating access services. *The Service signaling Domain* for all signaling with service per-se services. The *Call signaling domain* for signaling between Call Control functions. The *Bearer signaling domain* for signaling between bearer control entities. In legacy networks, the access signaling domain is taken care by MAP, the service signaling domain by INAP and the bearer signaling domain by Q931 and ISUP.

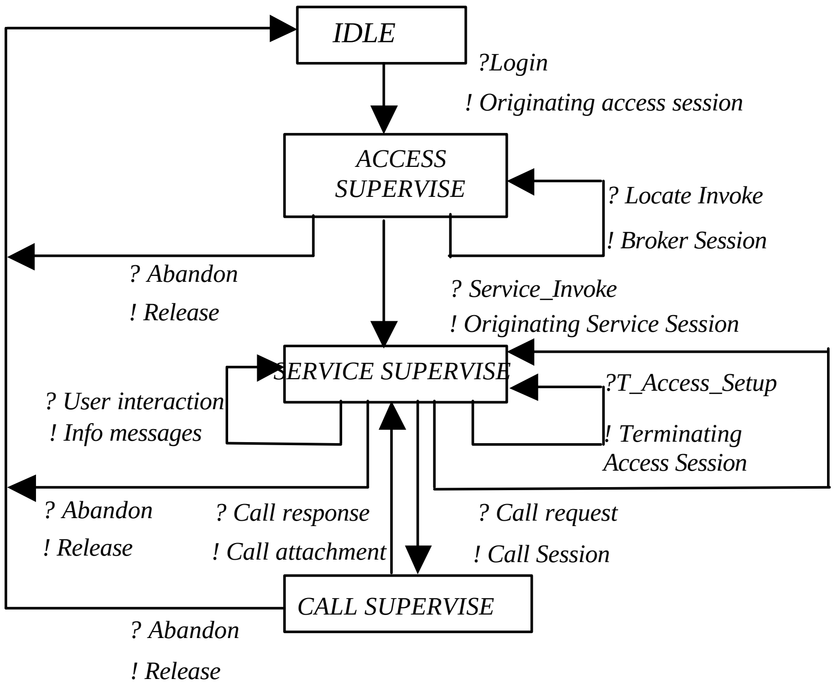

Figure 7 : Precedence principle and global sequencing scheme

9) Service Level separation and Global Service Sequencing

Service-Call separation as well as Call-Connection separation have long been considered a desirable research target so that services would not depend on a call model and call functions would not depend on a connection control model. Progress has been made towards these separation goals, without achieving full success yet. For example, the intelligent network approach, although achieving a considerable amount of service-call independence, does not achieve complete independence. When adding new services in a next Capability Set, the call model has to be changed to accommodate the new services, with the consequence of having to update all Service Switching Points.

In order to achieve total separation between service levels, it is necessary to have a true Client-Server relationship between these service levels. A fundamental aspect of Client server relationship is that the client initiates the relation. We derive then, from the SIMPSON model a *Precedence Principle according to which the Service Owner must precede the Service Provider, the Service Provider must precede the Service Operator, the Service Operator must precede the Network Operator, the Network Operator must precede the Bearer Operator*.

The precedence principle results in a global sequencing scheme for service execution represented by the finite state machine representation of figure 7. This diagram clearly represents the Client server relationship between the service levels and the network levels. This client server relationship is the key to the independence between these levels.

10) Conclusion

We have introduced in this paper the SIMPSON model, a generalized Client-Server model as a basis for Telecommunication and Networks service convergence. This model is a convergence model because it allows a generic implementation of control plane mechanisms, in a client server way, over a network type of bearer service. This model provides accurate definitions for the control plane functions as well as a method for organizing their relationships and insuring their separation. The emphasis has been placed on the client-server relationship. However signaling is a communication between peer to peer functions involved in the same global service session and sharing a common context. Instance data significance in this common context depends on call models that have to be identified. Existing call model proposals such as the (IN-CS1) standards (Call Legs), the Intelligent Network Capability Set 2 (IN-CS2) standards (Connection View States), the Computer Telephony (CTI) standards (Connection state representation), the IETF Session Initiation Protocol (SIP) Standards (SIP CGI, CPL) should be now analyzed for generalization.

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