

Evaluation of the IMS-based MSF architecture against network architectural requirements

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Abstract—Telcos are working toward an infrastructure that has a QoS enabled transport network; a softswitch type architecture for call or session control; and an infrastructure that enables applications to be generated and provisioned by a variety of providers. There have been many proposals such as TINA, TIPHON, H.323, SIP, etc. that address parts of the problem. The current incarnations of IMS is the choice for call and session signalling for example IMS within the MSF architecture. The ideal network architectural requirements have been defined to address the telco requirements. The MSF's IMS based architecture is evaluated against the generic architectural requirements by reviewing the characteristics of the architecture by analysis of the control messages for an assortment of call setup scenarios. Message Sequence Charts are presented for the call setup scenarios. The MSF architecture is found to be incomprehensive in providing for the future multiservice network requirements.

Index Terms—Network Architecture, MSF, IMS, SIP.

I. INTRODUCTION

TELCOs are working toward an infrastructure that has a Quality of Service (QoS) enabled transport network; a softswitch type architecture for call or session control; and a service platform that enables applications to be generated and provisioned by a variety of providers. The future multiservice network will be packet based [1], in addition, this future network must provision equivalent or improved levels of quality in comparison to current service provisioning [1,2]. Current Time Division Multiplex (TDM) infrastructure inherently guarantees service levels by provisioning a dedicated circuit end-to-end [2]. Similarly, packet-based network must guarantee QoS requests for every admitted end-to-end connection within the network.

The nature of TDM technology allows the telco to provision a variety of service offerings associated with a variation of service levels using the concept of an aggregation of dedicated elementary circuits (timeslots) provisioned at the network level. To achieve an equivalent level of service offering using packet based technology requires: i) guaranteed QoS provisioning between end-to-end points on shared infrastructure at the network level; ii) the ability of the telco infrastructure to provide a variety of

service requirements at the service level; and iii) an interfacing Connection Admission Control (CAC) element between the network and service levels that is aware of service requirements and the state of the network to make an admit or reject decision.

There have been many proposals such as TINA, TIPHON, H.323, SIP, etc. that address parts of the problem. Of these proposals, the current incarnations of the IP Multimedia Subsystem (IMS) is the choice for call and session signalling for example IMS within the 3GPP and MSF architectures. These proposals need to be evaluated against generic NGN requirements. In this paper, we first define the NGN requirements and then evaluate the MSF's IMS based architecture against these requirements.

Section II presents the ideal Network Architectural requirements as translated from the telco requirements. Section III details the methodology to be used in the evaluation of the MSF network architecture. Section IV describes the MSF architecture and its components. Section V presents a connection setup use case and Section VI details the analysis against the ideal network requirements.

II. NETWORK ARCHITECTURAL REQUIREMENTS

In order to design the future flexible network architecture (NA) that explicitly engineers the network for provisioning converged services, generic network architectural characteristics needs to be described. The network architecture is not a detailed definition. Rather it provides the concepts and principles for connections involving the constituent networks (packet and circuit switched) and single elements (media gateways and IVRs). The architecture must encompass the following characteristics [3]:

- be designed as a *simple* architecture;
- demonstrate *technology independence*;
- support *open interfaces*;
- enforce an integrated approach to *QoS* for end-to-end connections;
- implement *connection admission control* as part of the overall QoS assurance system;
- provision intelligent *routing* of connections;
- support *federation* between network operators to provide QoS-assured end-to-end connections;
- support *legacy* technologies in the overall architecture.

A. Simplicity

The NA must be designed in a manner that will ensure:

- Minimal architectural layers;
- Decisions to be made at the lowest layer

¹ The Centre is supported by Telkom SA Limited, Siemens Telecommunication and the THRIP Programme of the Department of Trade and Industry

- possible (efficiency);
- Hierarchical tree structured architecture;
- Minimise on overhead messages (efficiency).

These characteristics will ensure that minimal data traverses between layers, it also defines the functional processing components in each layer within the architecture. Overhead messages can contribute to a significant reduction the available capacity for customer usage.

B. Technology Independence

The rapid deployment of converged technologies results in a diverse assortment of technologies within the industry. Associated with each technology are specific protocols and the resultant is a host of assorted protocols on the network. The evolving nature of the telco NA results in a number of specialised elements required to deal with the complexity and translation of the assortment of protocols, for example the media gateway. The current status of telco operation results in an unscalable NA and limits the future proofing of the architecture.

C. Open Interfaces

Service Orientated Architectures are leverage on the fast development of services in the information technology world. Service architectures such as OSA/Parlay define open interfaces wherein 3rd party application developers can develop advanced services without detailed knowledge of the underlying network architecture, using a level of abstraction provided by the Application Programming Interface (API) mechanism. This mechanism can be replicated within the architecture as technology independent interface between various network components hence contributing to the future proofing of the architecture.

D. QoS

The present envisaged implementations of various architectures rely on network-level mechanisms to negotiate and agree of QoS parameters, for example session description carried within SIP messages. Application-related QoS is however the ultimate goal. The ideal operation of the telco is described in the following steps. The application requests the required QoS. Using parameters that are suitably abstracted from the underlying infrastructure, the service provider specifies the maximum QoS that it offers. This level may be specified in policies and may depend on the state of the network. The service provider and application agree on a quality. At the network level, end-to-end interactions may be necessary to determine the QoS available. If the requested quality cannot be provided, the request may be refused, for example a call request is not admitted. The underlying network mechanism must record the QoS achieved for billing and management purposes.

E. Connection Admission Control

Connection admission control (CAC) ensures that prior to its admission; a new connection awaiting to be admitted into the network is guaranteed a level of QoS within the network for the entire connection duration. The new connection is associated with a logical class of traffic within the network. The CAC determines whether the

specific class within the network has sufficient capacity and demonstrates ideal performance parameters in terms of performance metrics. In addition, the CAC provides a secondary function ensuring existing connection will not deteriorate in quality due to the new connection entering the network.

F. Routing

The NA must incorporate intelligence into the routing requirements for connection requests. Presently, current packet switched networks incorporate routing protocols which signifies that the packet technology layer within the network provides the routing of connections using common routing protocols. Thus the network architecture has little or no control of the manner connections are setup and rerouted upon failure.

In order to ensure guaranteed QoS for connections within the telco environment, an engineering approach to routing is required. This requires a function to setup connections within the network based on QoS parameters. Link failure resulting in rerouting traffic must adhere to network routing principles and QoS performance of the existing connections allocated to the failed link.

G. Federation

Telecommunication operators are often required to federate networks in order to provide an effective service to their users. This would include the federation of local networks for consumers to contract each other notwithstanding the separate networks. Similarly, international calls require an interworking of operators networks. Due to the trend of rapidly evolving technologies, it is not uncommon to have interconnection requirements for a call with varying technologies along the path. This requirement needs to ensure that the end-to-end QoS required for the service can be guaranteed for the entire duration of the connection.

Added to the complexity, operators would implement an assortment of architectures, these scenarios need to be addressed within the NA.

H. Legacy

Telco networks consist of large number of assets associated with large financial investments. Due to the nature and size of the network, telcos can not adopt a fork lift approach to replacement of technologies already deployed within the network. In addition, many technologies have a significant investment value attached and financial decision require the technology to be fully repaid before migration to newer technologies. Thus it is often the case that many telcos have to deal with incorporation of legacy technology into the new NA. The design of the new NA must be in keeping with the NA characteristics mentioned above.

III. EVALUATION METHODOLOGY

Present available network architectures provide for adaptation of the new converged services on non-ideal infrastructure. The objective is twofold, i. an audit of the existing available architectures with analysis of the network characteristics and ii. Identify well engineered reusable components of the architectures that can be used to develop

the new NA. Present architectures consist of TINA, THIPON, 3GPP and MSF.

The approach adopted is to review the characteristics of the architecture by analysis of the control messages for an assortment of call setup scenarios. Message Sequence Charts (MSCs) will be presented for the call setup scenarios and these will be evaluated against the network characteristics outlined in Section II above.

Analysis of the MSCs provides insight into the architectures. The number of control messages provides an indication of the overhead and simplicity of the architecture. Control messages emanating from gateway devices provide insight into the complexity of the network elements required to support an array of various protocols. The message flows specifically addressing the QoS requirements of the connection will indicate whether the QoS mechanism is an integral part of the architecture and whether the architecture can guarantee QoS requirements end-to-end. Closely coupled to the QoS mechanism is the maturity of control messages dealing with the CAC function.

Routing implementation will be quickly ascertained from the MSC by determining whether the architecture expects the packet switched technology to “automatically” route connection or whether an engineered approach is adopted. Federation of network provides insight into the complexity of the overhead messages and insight into whether QoS can be guaranteed end-to-end. Use cases dealing with legacy devices provide insight into whether the architecture clearly supports legacy technologies with the characteristics as described in Section II.

IV. MULTISERVICE FORUM ARCHITECTURE

The objective of the MSF is to speed up the deployment of NGN infrastructure by ensuring a multivendor environment based on interoperable standards [4]. This is accomplished by incorporating practical technologies to fully realize the earliest deployment of NGN networks. To this extent, the MSF has defined an all encompassing architecture incorporating latest technologies (standards) and addressing architectural matters such as QoS and Security [4]. The MSF has also defined a number of signaling protocols between various components of the architecture, however this definition is not comprehensive [4].

The MSF has recently published release 3 of their architecture (see figure 1). The revision incorporates IMS components [4]. The general architecture consists of 6 domains: customer equipment, transport, call & session control, common resources, applications & services and the federation domain.

The MSF specifies [5] the Customer Equipment domain consisting of static, nomadic and mobile equipment. These terminals need to interface with the network utilising network edge devices. All equipment within the Customer Equipment domain are regarded as untrusted from the telco perspective. The legacy (POTS/ISDN), residential gateways (RGW) and Basic SIP terminals are registered with the Call Agent (CA) and the Home Subscriber Server (HSS). While the 3GPP and IMS-aware terminals are registered on the Serving Call Session Controller (S-CSC) and the HSS. The

IMS-aware terminals in addition are registered on the Subscription Locator Server (SLS).

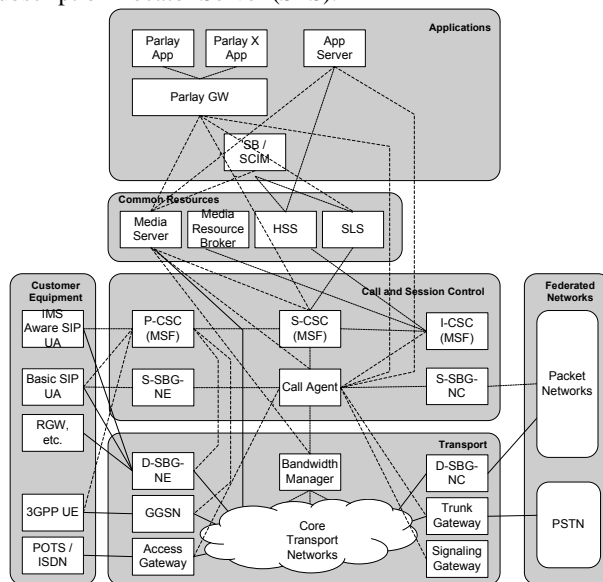


Figure 1: MSF Architecture – Release 3 (sourced from [5])

Basic SIP and RGW devices signal using SIP and MGCP protocols respectively to communicate with the Signalling Path Session Border Gateway, Network Edge (S-SBG-NE). The IMS-aware SIP UA and 3GPP terminals utilise an advanced adaptation of SIP to communicate with the Proxy Call Session Controller (P-CSC). POTS/ISDN terminals interface to the Access Gateway (AGW) for both bearer and signalling. IMS-aware SIP, Basic SIP and RGW equipment interface to the Data Path Session Border Gateway, Network Edge (D-SBG-NE) for bearer connections. While the 3GPP UE interfaces to the Gateway GPRS Supporting Node (GGSN) for bearer connections.

The Transport domain is primarily responsible for the bearer connections within the architecture. Edge domain elements provide QoS functions (admission control, packet marking and resource allocation), mediation to other domain elements, Network Address Translation (NAT) and flow measurement. The D-SBG-NE, GGSN and AGW provide bearer interfaces to customer equipment domain terminals. Similarly, the Data Path Session Border Gateway, Network Core (D-SBG-NC), Trunking Gateway (TGW) and Signalling Gateway (SGW) fulfil edge interface functionality to federated packet networks and the PSTN. The Core Transport Network routes traffic between end points, it provides a QoS guarantees for connections by the implementation of the admission control function of the BM. The BM is the single point of contact for requests to utilise the core transport network. It is aware of network state by liaising for network components, using this information to provide the admission control function, however the interface protocols are not defined.

The Call and Session Control domain provisions the initial signalling points for customer terminals, the signalling points for federated networks and elements required to orchestrate calls and sessions within the network. The P-CSC provides initial signalling points for the IMS-aware SIP and 3GPP user terminals, while the S-SBG-NE provide

initial signalling points for the Basic SIP and RGW devices. The Signalling Path Session Border Gateway, Network Core (S-SBG-NC) is the signalling interface to federated packet based networks. The CA provides session setup, control and tear down and has access to routing information for this purpose. It is responsible for the billing and invokes services from the service domain. Similarly the S-CSC provides all the CA functions specifically for the IMS-aware SIP UA and 3GPP UEs. The Interrogating Call and Session Controller (I-CSC) is the responsible proxy element for incoming session from federated IMS type networks and is used to interrogate the HSS and SLS for user information.

The Common Resources domain contains common elements frequently used to fulfil ordinary session and call requests. The HSS is the master subscriber database of the telco, it contains specific subscriber information. The SLS is dedicated to location information of the mobile terminals. The Media Server (MS) provides resources such as special tones, IVR type announcements, conference bridging and automatic speech recognitions. The Media Resource Broker (MRB) provides brokering services to located specific MSs.

The Application domain consists of advanced services. These services are provisioned in the Application Servers (AS), Parlay Applications and Parlay X Applications. The Parlay Gateway and Parlay X Gateway act as SIP Application servers. The Service Broker (SB/SCIM) provides brokering service to locate specific applications.

The Federated domain consists of the legacy PSTN network accessed by the SGW (signalling) and TGW (bearer). The architecture makes provision for the interworking with packet based federated networks utilising the S-SBG-NC (signalling) and D-SBG-NC (bearer).

V. USE CASE

A. IMS aware SIP to IMS aware SIP Call

The control messages used to setup the call is depicted in figure 2. The User Agents (UAs) are within the same administrative domain, the network entities conform to the architecture defined in figure 1.

The call setup sequence is described as follows:

- 1,2 The originating UA sends a SIP INVITE message to the P-CSC. The proposed connection parameters are carried within the SDP message. The 100 TRYING message assures the UA that the invite is being processed.
- 3-4 The SIP INVITE message is forwarded to the S-CSC the entity required to orchestrate the call setup. The S-CSC similarly reassures the P-CSC that the invite message is being processed.
- 5-8 The S-CSC requires the location information of the terminating party. A request is sent to the I-CSC to interrogate the HSS database for the location of the terminating party. The results are forwarded to the S-CSC via the I-CSC.
- 9-16 The S-CSC must determine whether sufficient resources exist to service the connection request within the core transport network. The enquiry request is sent to the BM via the CA, in turn the BM interrogates network elements (routers) for end-to-

end network status. The results are returned to the S-CSC via the CA from the BM. We deal with the positive result scenario.

- 17-20 The S-CSC now extends the SIP INVITE message to the terminating P-CSC and party. The associated 100 TRYING messages provides the sending entity assurance that the invite is being processed.
- 21,22 The terminating party provides an Offer Response message associated with the initial SDP offer using the SIP 183 Session Progress message
- 23,24 On receipt of the SIP Offer Response message from the terminating party, the S-CSC invokes logic to incorporate network constraints. The modified Offer Response message is sent towards the Originating party via the P-CSC
- 25-32 The originating UA's positive confirmation to the terminating UA's media offer is sent in a Response Confirmation, implemented as a SIP Provisional Acknowledge or PRACK method. The terminating party acknowledges the confirmation with a Confirm Acknowledge message, implemented using the SIP 200 OK message.
- 33,34 On receipt of the SIP 200 OK, the originating party sends a forward Resource Confirm message (SIP UPDATE).
- 35-42 At the S-CSC the SIP UPDATE indicates that the media negotiation has been finalised. The S-CSC invokes the resource reservation: the S-CSC engages the CA to reserve resources in an Authenticate and Authorize Request (AAR). In turn, the CA engages the BM to reserve the appropriate resources. The BM instructs the appropriate network elements to reserve resources.
- 43,44 Upon receipt of the positive confirmation from the BM via the CA, the S-CSC forwards the resource confirmation message (SIP UPDATE) towards the terminating party.
- 45-48 The terminating party responds with a reverse direction Resource Confirmation (SIP 200 OK) conveying confirmation of the reservation. The end-to-end path is now reserved and provisioned with the required connection QoS.
- 45-48 The terminating party responds with a reverse direction Resource Confirmation (SIP 200 OK) conveying confirmation of the reservation. The end-to-end path is now reserved and provisioned with the required QoS for the connection
- 49-52 The SIP 180 RINGING message indicates the terminating parties alerting state.
- 53-56 The SIP 200 OK message indicates the terminating party's off-hook status.
- 57-60 The connection setup is completed by the SIP ACK sent to the terminating party.

VI. ANALYSIS AGAINST ARCHITECTURAL REQUIREMENTS

We have presented a simple use case for call setup within an IMS based architecture. The architectural characteristics are ascertained based on the characteristics of the control messages used to setup the connections.

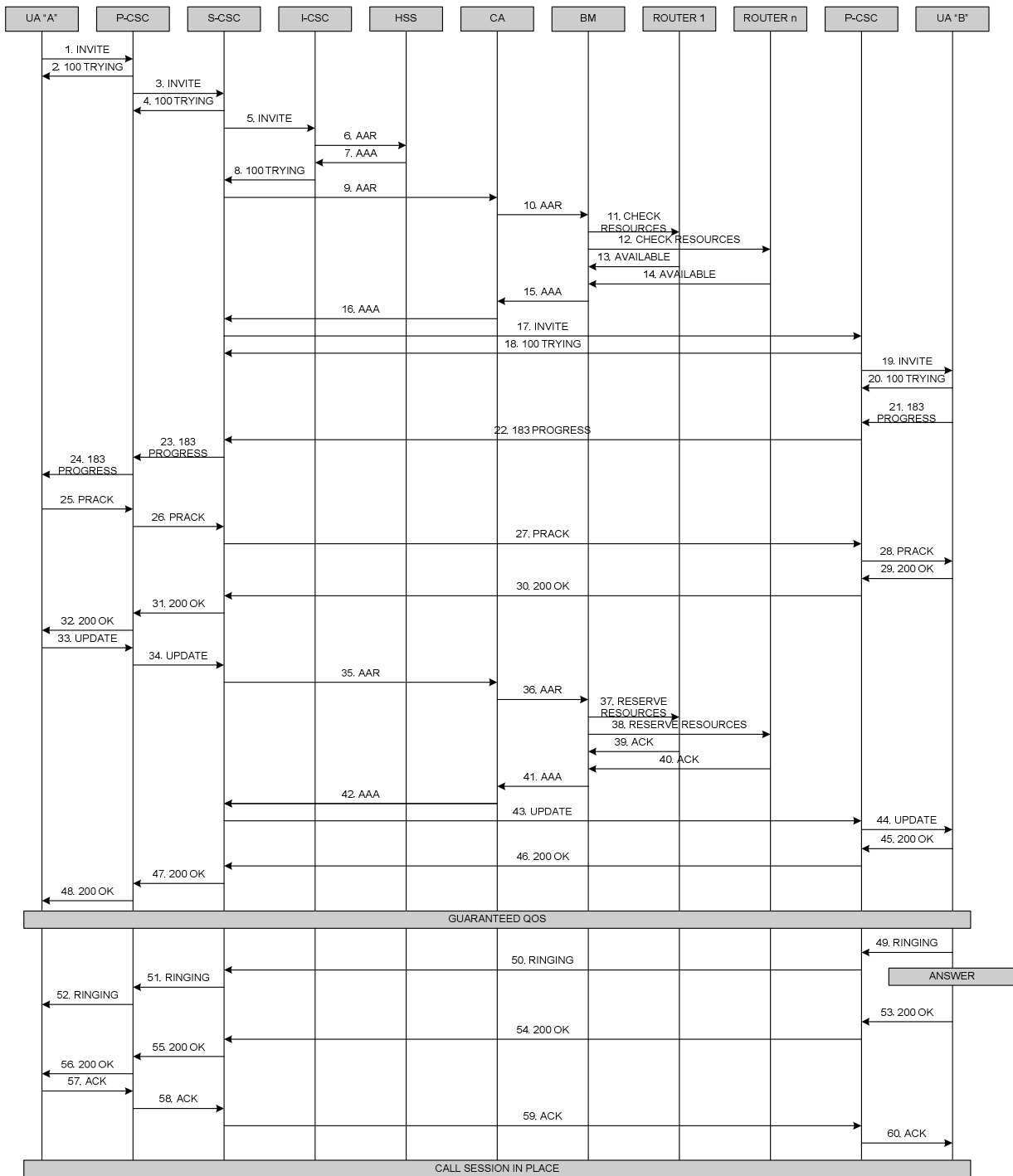


Figure 3: IMS-aware SIP to IMS-Aware SIP Call

A. Simplicity

Telcos implementing new architectures to service the future customer requirements must service the basic requirement of providing equal or better levels of service as compared to its predecessors. The large number of control messages required to setup basic calls within the same administrative domain translates into a large network overhead within the architecture. By comparison to ISUP messaging used with the PSTN environment, the IMS based architecture is unnecessarily complex. The opportunity costs of the architecture are significant, when

considering the loss of revenue of customer usage due to the significant signalling overheads.

The architecture depicted in figure 1 has many redundant elements, in particular the S-SBG-NE and CA configuration are SIP based elements. While the P-CSC, S-CSC and I-CSC are components of the IMS, also SIP flavoured elements. The interworking of these elements within the call control functions is a point of difficulty (see figure 2).

The MSF architecture attempts to cater for all technologies and standards such as VoIP, SIP, IMS, mobility, etc. The result of the all encompassing

architecture is the number of dedicated gateway elements and complexities to deal with each call scenario.

B. Technology Independence

The architecture in an attempt to incorporate most technologies is very technology dependant. To this extent, the MSF has not defined protocols for the QoS assurance components of the architecture. Thus the difficulty of mapping signalling messages used by the CA, BM and signalling to the network elements for resource reservation as well as admission control. Many of the interfaces between network components are SIP dependant. In addition many technology specific elements are defined within the architecture making the architecture unscalable and future limiting.

C. Open Interfaces

Much of the architectural interfaces are SIP dependant. In particular the interface between the Service Broker and Application Server as well as the Service Broker and the Parlay Gateway is SIP based. Protocols are technology dependant and are limited by the definition of the messages contained therein. The SIP protocol in particular, requires the application developer to have intricate knowledge of the network to design services.

D. QoS

The objective of the QoS components in the MSF architecture is an engineering approach to QoS. However, as depicted within the call setup use cases, the SIP protocol dictates network-level QoS mechanisms. This is evidenced in the negotiation between end parties of media streams and QoS parameters. The QoS components are thereafter required to query the state of the connection path for every call request. The architecture is inflexible in achieving application-related QoS.

E. Connection Admission Control

The MSF describes its intention to provide access control on the edges of the core transport network. However, the interface protocols to achieving this end remains undefined. Thus the CAC mechanism is not achieved as supported in the use case diagrams.

F. Routing

The architecture is reliant on the transport network technology. The MSF has specified MPLS as the technology of choice. However, the MSCs show that the architecture is reliant on the routing mechanism of the underlying transport network technology.

G. Federation

The architecture provides for specific interfaces for federation both with TDM and Packet based operators. However, from call setup scenarios across administrative domains results in a proliferation of signalling messages to setup a connection implying large signalling overheads. Specifically, interconnecting into a MSF type network results in mirrored control messages hence doubling the number messages. In addition, QoS can not be guaranteed for the end-to-end connection.

H. Legacy

The MSF architecture provides for a number of gateway elements to address the requirement of integrating legacy technologies into the architecture. In particular, the PSTN has been provisioned. However, since the MSF has defined the interface using ISUP based messaging thus architecture limitation in terms of the reuse of PSTN IN platforms.

VII. FUTURE WORK

The intent of future research work is to define a network architecture that meets the requirements of service delivery platforms. In order to achieve this end, the architecture must present open network interfaces for services as well as abstract network information to the service interface. The architecture will also address the aspects of 3rd party application initiated calls.

VIII. CONCLUSION

Telcos anticipate that the future multiservice network will comprise of infrastructure that has a QoS enabled transport network; a softswitch type architecture for call or session control; and an infrastructure that enables applications to be generated and provisioned by a variety of providers. Detailed analysis of the requirements of the future network identifies architectural requirements of: *simplicity, technology independence, open interfaces, integrated QoS, connection admission control, engineered routing and support federation as well as legacy equipment*. Many proposals have been made to address part of the requirements; in particular IMS based architectures are common. We evaluate the MSF's IMS based architecture against the telco requirements by analysis of signalling messages. The MSF proposal is ineffective in dealing with all the telco requirements.

REFERENCES

- [1] Moodley, P., and Kennedy, I.G., "A position paper: Modelling selfsimilar traffic", ICT 2005 - 12th International Conference on Telecommunications 3-6 May 2005, Cape Town. © 2005 IEEE. ISBN: 0-9584901-3-9 Reprinted in Trans SAIEE.
- [2] Hanrahan, H.E., Network Convergence: Services, Applications, Transport, and Operations Support, 2007, John Wiley & Sons, Ltd.
- [3] Moodley, P.V., and Hanrahan, H.E., "Design of a Parlay Network Application Programming Interface and Associated Architecture", Southern African Telecommunications Networks and Applications Conference (SATNAC) 2006 Proceedings, September 2006.
- [4] MultiService Forum, "MSF Release 3 Architecture", June 2006, www.msforum.org
- [5] Gallon C, "Quality of Service for Next Generation Voice Over IP Networks", MultiService Switching Forum, February 2003, www.msforum.org

BIOGRAPHIES

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