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Softswitch Multicriteria Analysis for Software Quality based on IPCC Reference Architecture

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Abstract— **Quality of service (QoS) is difficult to achieve in modern voice over IP (VoIP) systems because software and hardware have a symbiotic relationship. The purpose of this paper is to present an analysis of softswitch quality that identifies where higher quality requirements should be enforced when designing or evaluating VoIP solutions. The work is based on the international standard ISO/IEC 9126 and the International Packet Communications Consortium (IPCC) reference architecture. Therefore, it applies to most vendors and architectures regardless the underlying technology. Since the softswitch is fairly complex and involves many software and hardware modules, quality attributes have been analyzed through their functional behavior. This paper provides softswitch vendors and buyers with results that will help them make better resource allocation decisions and therefore reduce both their capital and operational expenses.**

I. Introduction

To improve *Quality of Service* (QoS) most of the research is currently being done by network engineers. Their primary focus is on routing improvement, lowering latency and having call admission control (CaC) equivalent functionalities for the IP Networks. While these efforts have had a good impact on the QoS they are not sufficient to have high quality VoIP systems. Although network hardware for VoIP keeps improving, the software part has been overlooked by many system engineers.

Currently, softswitch vendors try to solve software quality-related problems like state keeping, lost billing records or fraud through their externalization, for example by putting additional data redundancy or special firewalls. Other approaches taken in order to improve software quality of a softswitch, like these presented by Lundberg and al. [3] usually focus on separate quality analysis and improvement of a part of the architecture while the softswitch treated as a whole still suffers low quality. The main purpose of this paper is to present the areas of the softswitch functional architecture that are the most critical with regards to quality and provide the recommendations for their required improvements in order to produce high quality softswitches. The tools used for this analysis are two parts of the international standard ISO/IEC 9126 - Part 2 (External Quality Metrics) [6] and Part 4 (Quality in Use Metrics) [7]. In the following sections this paper presents the description of the reference architecture used as a basic reference, explains the applied analysis methodology, discusses the obtained results and, in the conclusion indicates possible continuations of this research.

II. Reference Architecture

In order to provide an evaluation that can be applied to most softswitch solutions the reference architecture from IPCC (International Packet Communications Consortium) has been used [9] for the analysis purposes. This reference architecture presents a functional view of a general architecture that may be considered as representative to most softswitches. The level of abstraction allows a prospective user to apply the results of this research to most of known softswitches to evaluate their quality or to build one correctly.

A. Operation Planes

(Fig. 1). The IPCC Reference Architecture is composed of 4 different planes. Each of them depends on the underlying planes as depicted on Fig. 1. This allows for the differentiation of implementation technologies that can be acquired from independent vendors. Therefore, the planes can be analyzed and built separately even if a strong dependency exists between them. The software modules used by the softswitch solution may belong to many planes at the same time but the functionalities provided will always respectively belong to a specific plane.

Seen at the bottom of the above structure is the layer of the transport plane. This layer's performance depends mostly on the network and the way VoIP traffic is being handled. It involves all the IP and non-IP traffic required to enable the softswitch operation. It is also this layer that will do interworking between network communications and signaling protocols (e.g SS7) of a traditional Public Switch Telephone Network (PSTN). Since control and data information depend on the proper functioning of this layer, it may be considered as the most important layer of a softswitch.

On top of this layer resides the call control and signaling plane. This plane is responsible for managing and controlling all the signaling and routing information needed to initiate, monitor and terminate the data flow between communicating pairs.

Finally, the plane that resides on the highest level is the service and application plane. On this level a softswitch exposes the interface between the user and the voice system. This layer provides the normal usage interface like placing phone calls but also provides access to advanced functionalities like conference calls, voice mail and call forwarding.

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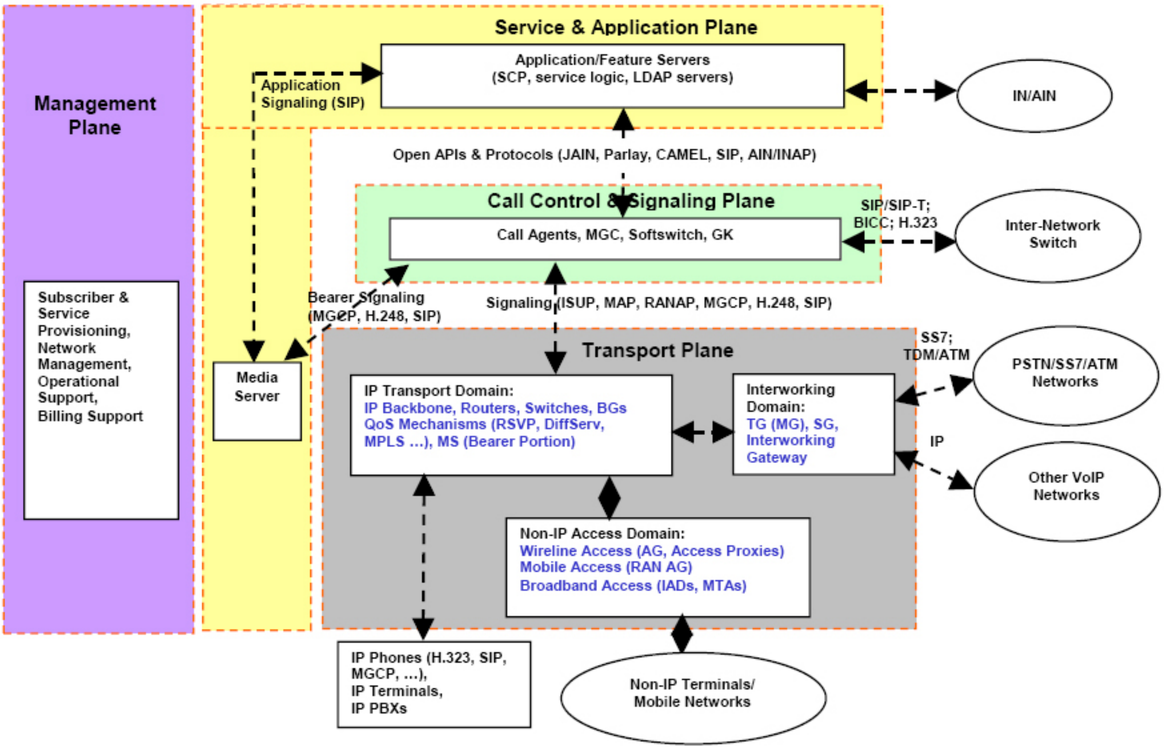

Fig. 1. Operating Planes of a SoftSwitch [9]

It is important to mention here that due to the external nature of the management plane it has not been taken into consideration as in most of softswitch implementations it varies from one vendor to the other.

B. Functional Entities

The different planes are divided into functional entities that have a special role in the overall system. A Functional Entity consists of functional elements and may belong to different planes at the same time. A functional element is the functional role that must be fulfilled by a functional entity in order to behave correctly in the reference architecture.

Fig. 2 shows the softswitch structure where functional entities belong to many planes at the same time but have only one single role that belongs to a single plane of operation.

The following list describes briefly the role of each functional entity:

- AS-F: Application Server Function - Provides application the interface to the system.
- SC-F: Service Control Function - Subset of the SC-F.
- CA-F: Call Agent Function - Subset of the MGC-F.
- MGC-F: Media Gateway Controller Function - Provides the call state machines.
- SPS-F: SIP Proxy Server Function - A joint version of R-F and A-F for SIP.
- R-F: (Call) Routing Function - Determines the routes to take to establish the call.
- A-F: Accounting Function (e.g., AAA) - Manages call records and necessary accounting signals.
- MS-F: Media Server Function - Provides functionalities like voice-mail and on-hold music.
- SG-F: Signaling Gateway Function - Translates signaling information from VoIP systems to PSTN.
- MG-F: Media Gateway Function - Translate voice information between domains.
- IW-F: Interworking Function - Works with the CA-F to provide MGC-F functionalities.
- AGS-F: Access Gateway Signaling Function - Translate signaling information between circuit switched networks and VoIP systems.

The above functional entities are required to design most of known types of softswitches.

C. Identification User Types

From the perspective of a functional complexity of a softswitch several different types of users could be identified:

- the end user placing the call,
- the traffic user responsible for managing the network resources usage,
- the provisioning user that allocates the resources, phone number and initiate the billing information.
- the billing user responsible for all billing activities.

The above identification is required to properly rate the quality of a softswitch both in the category of Quality in Use (an end user point of view) and External Quality (a technical/operational point of view).

Easily identifiable relationships exist among all the types of users of a softswitch. The quality and effectiveness of operation of a provisioning user will impact

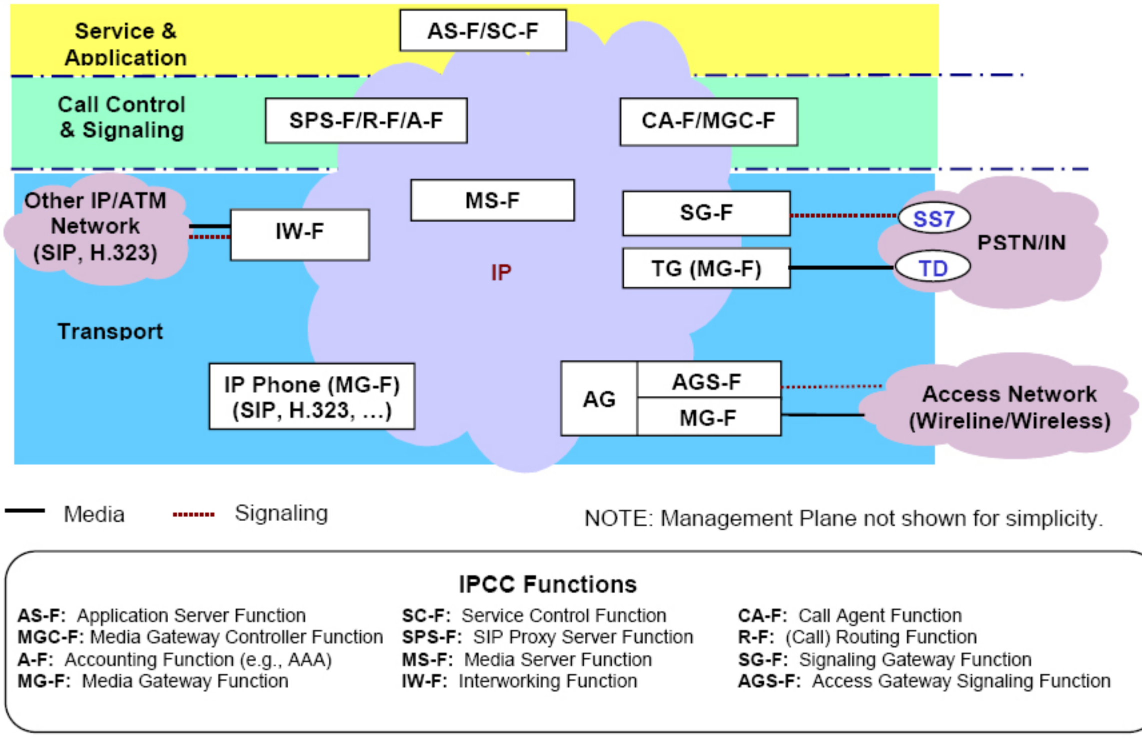

Fig. 2. Functional Entities of a SoftSwitch [9]

the way in which the softswitch can be handled by the traffic user. There is also a strong relationship between the provisioning user and the billing user. Taking the above into account the following could be concluded: the overall perception of the softswitch and its quality is affected principally by the ability of billing and traffic user to do their tasks correctly. This means that evaluating traffic and billing user's perception should allow for a relatively good overview of the softswitch's quality. This conclusion constitutes the reason why the presented research focused on these two types of users.

III. Description of the Methodology of Research

The principal objective of the proposed method is to analyze the functional requirements in order to produce a list of quality requirements applicable to these functional requirements. The applied research methodology is based on ISO/IEC 9126 - Part 2 (External Quality) and ISO/IEC 9126 - Part 4 (Quality in Use) documents. The methodology is a three phase approach shown in Fig.3. The consecutive phases describe in detail the impact of poor quality of functional elements on the overall system, provide the rating required to evaluate this impact and finally normalize the obtained results using the AHP methodology (Analytic Hierarchy Process) published by Satty [2]. The normalized results are then transferred into the polar representation to facilitate the synthesis and use.

A. *Scope of the analysis*

The applied methodology focuses principally on functional behavior of a softswitch aiming to provide a set of desired quality metrics related to identified softswitch functionalities. External issues not controllable by the software quality model described in ISO/IEC 9126 Part 1 [5] (e.g. network latency, echo cancellation, call admission control) were not a part of the research presented in this paper.

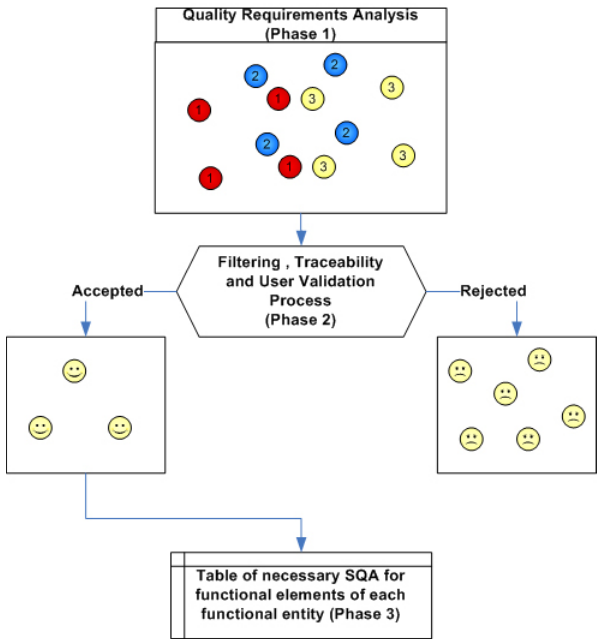

Fig. 3. Methodology of the analysis

B. Phase I - Functional Entity Analysis

In its first step the method analyzes each functional element and evaluates the impact of poor quality on the overall behavior of a softswitch applying the measures from ISO/IEC 9129 Part 2 and ISO/IEC 9129 Part 4. This detailed analysis was applied to all 54 functional elements that constitute the core of the softswitch architecture.

To assure objectivity and consistency of the analysis the dedicated reasoning methodology presented in Fig. 4 was applied.

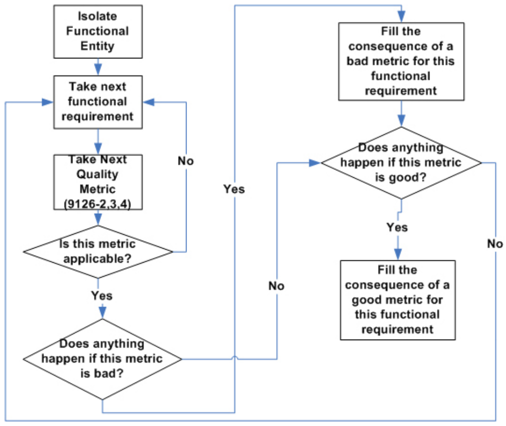

Fig. 4. Phase 1 - Reasoning Technique

C. Phase II - Filtering and Rating

The second phase of the methodology focused on the evaluation of the results obtained in Phase I. To assign ratings to the different quality factors a case-by-case analysis of the impact of poor quality for each of the functional elements on the overall softswitch behavior had to be applied. Initial filtering was done through the application of a telecom-specific "functionality reliability" technique based on telecom industry ratings (Fig. 5).

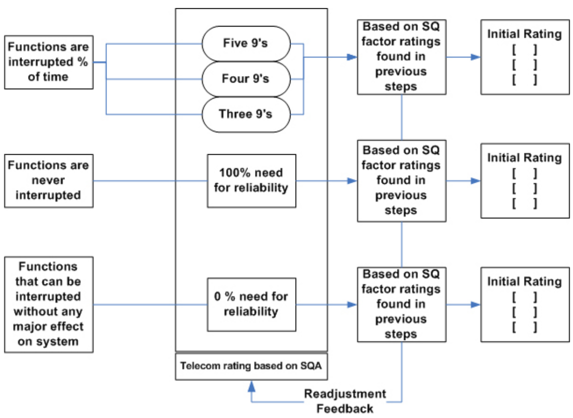

Fig. 5. Phase 2 - Filtering and Rating

Both traffic and billing user's rating grades are shown in table II, they show the importance of the evaluated metric with a number from 1 to 5.

D. Phase III - Software Quality Attribute Synthesis

The last phase of the methodology is to normalize the results using the AHP Analysis Methodology based on the factor of importance described in Phase II. The ratings are based on user type-related evaluation of softswitch's capabilities to perform his function. Ratings that have a score higher than 3/5 are considered as a required SQA in the analysis after filtering. They are shown in the Table III (Important Metrics for Functional Entities) containing the SFE and SQA for this type of user.

IV. Results

The Software Quality Attributes (SQA) for the billing and traffic users take into account both the quality in use view and the links between the quality in use and the external quality that can cause problems to its important Quality in Use SQA.

A. Quality in Use for Billing and Traffic Users

The following polar graph shows the importance of the different software quality attributes for billing user as based on the mean values of all the different functional elements for a specific quality characteristic.

It can be seen that for the billing user (Fig. 6) the most important quality aspects are the effectiveness, productivity and safety.

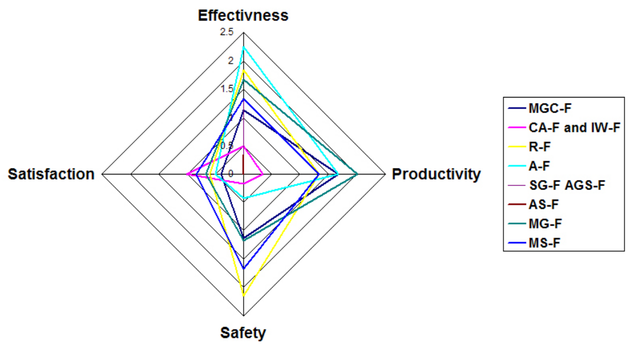

Fig. 6. Quality In Use required for billing user

It may also be seen that the traffic user has different needs for quality in use (Fig. 7) than the billing user.

TABLE I
Rating for External Quality

Transport Plane	4-5
Signaling Plane	3-4
Basic Services	2-3
Advanced Services	1-2

TABLE II
Rating for Quality in Use

Extremely Important	4-5
Very Important	3-4
Important	2-3
Unimportant	1-2

Indeed, the Routing Function (RF) is predominant and strives at effectiveness and productivity.

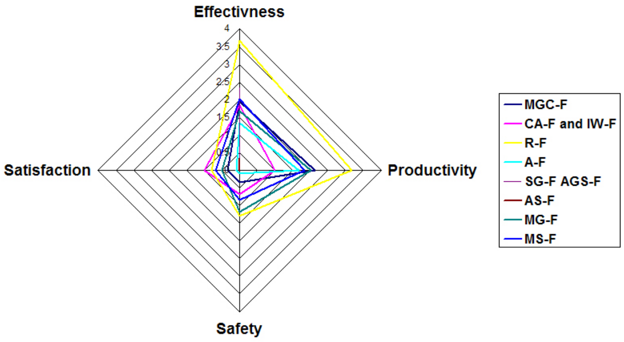

Fig. 7. Quality In Use required for traffic user

B. External Quality

External quality needed for the functional entities of the switch is shown in the graph (Fig. 8). The signaling gateway is the most critical functional entity for the system and quality should be oriented toward reliability, maintainability and functionality. Another important aspect is that the media gateway has to have high efficiency , which is required due to the fact that this entity does most transcoding and processing functions.

C. Functional Entity Quality Distribution

The distribution presented in Fig.9 illustrates how resources could be allocated in order to offer a high quality softswitch (Fig. 9) at the lowest cost possible. The traffic user would seek for more quality in the media gateway controller and the routing controller while the billing user would seek for quality of the accounting function, the routing function and the media gateway controller.

TABLE III
IMPORTANT METRICS FOR FUNCTIONAL ENTITIES

SoftSwitch Functional Entity	Software Quality Characteristics to Evaluate
MGC-F	Reliability Functionality Efficiency Productivity *(Traffic)*
CA-F	Reliability
R-F	Reliability Functionality Efficiency Safety *(Billing)* Effectiveness *(Traffic)* Productivity *(Traffic)*
A-F	Functionality Effectiveness *(Billing)*
SG-F and AGS-F	Reliability Functionality Maintainability Effectiveness *(Traffic)*
AS-F	Usability
MG-F	Efficiency Functionality Usability Productivity *(Billing)* Safety *(Billing and Traffic)*
MS-F	Functionality Reliability

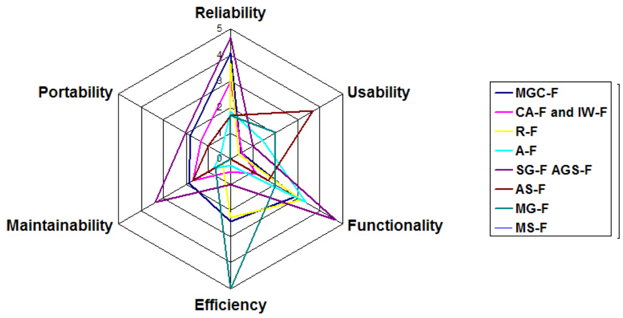

Fig. 8. External Quality Requirements

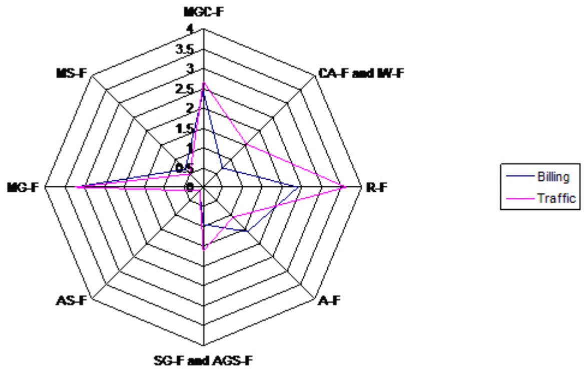

Fig. 9. Functional Entity Quality Distribution

V. CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK

This paper presents the results of the high level analysis of a softswitch architecture and its functional entities in order to identify quality attributes and related measures exhibiting the highest impact on the overall operation of a softswitch. To allow for fast, practical use of the results of this research the concluded observations are presented in form of polar graphs. The foreseen continuation of this research will focus on developing the quality engineering techniques allowing for an implementation of quality aspects identified in this paper as critical. École de technologie supérieure and Waveroad Canada consider forming a joint laboratory having for objectives to continue the research published in this article and to further explore the subject of softswitch quality in industrial environment. The new laboratory, if established will also offer different quality-related services to the telecommunication sector.

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