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# Framework for performance analysis of Home Subscriber Server

Sriraksha H R
*Dept of ECE*
*BMS College of engineering*
*Bengaluru-India*
*srirakshahr.1999@gmail.com*

Veena M B
*Senior member,IEEE*
*BMS College of Engineering*
*Bengaluru-India*
*veenamb.ece@bmsce.ac.in*

***Abstract***

In order to evaluate the performance of the mobile networks it is necessary to consider subscriber data management of the LTE subscriber. Home Subscriber Server (HSS) being the main core of the IP multimedia subsystem (IMS), responsible of handling the subscriber related data. This paper presents few major robustness scenario which causes the performance degradation of the HSS. Framework is developed to analyze the performance and to automate steps involved in analyzing the performance. One major robustness scenario is HSS blade power consumption during the different loads, since power reports of the blades are routinely used to monitor and to set the point of reference to evaluate the performance of the HSS. Therefore, these measurements must be accurate for network escalation and time to summon the Power consumed must be quick. This paper presents power measurements of the LTE networks by using iLO processor. Few more scenarios which causes the failure in HSS are, interface delay in Hardware Security Model (HSM) LAN and Light weight Directory Access Protocol (LDAP) LAN. Simulation of LTE networks is simulated through proprietary traffic generator tools

***Keywords****— HSS, iLO , HSM, LDAP, proprietary traffic generator tools*

## I. INTRODUCTION

In contrast to the circuit switched networks of previous Cellular networks. Long Term Evolution (LTE) has been designed to support only packet-switched network services. It aims to provide consistent Internet Protocol (IP) connectivity between user equipment (UE) and the packet data network (PDN), without any disruption to the end users applications during mobility. With the evolution in the cellular networks subscriber accessing these services also drastically increasing. HSS being main core of the IMS network, it holds all the services and features correlated with the user. HSS also integrates users subscription data such as the evolved packet system (EPS), subscribed quality of service(QoS) profile and any access restrictions for roaming. It also holds information about the PDNs to which the user can connect. This could be in the form of an access point name (APN) (which is a label according to DNS naming conventions describing the access point to the PDN) or a PDN address (indicating subscribed IP address(es)). In addition HSS holds dynamic information such as the identity of the MME to which the user is currently attached or registered. HSS also integrate the authentication center (AUC), which generates the vectors for authentication and security keys. In order to evaluate the performance of the LTE network introductory failure is faced in fetching the subscriber data from the HSS in the telecom industry.

The previous work describes about optimize protocol performance in mobile data networks it is essential to be able to accurately characterize two key network properties queue length and buffer size of the bottleneck link. This work tackles the challenge in estimating these two network properties in modern mobile data networks[1]

This work gives the complete solution or network slices planning of the LTE Evolved Packet Core (EPC), which is tailored for the enhanced Mobile Broad Band (eMBB) use case. A framework is designed for workload generation process and Holistic analytical models to predict the performance



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(e.g., packet loss probability and response time) of a virtualized evolved packet core (vEPC) is discussed[2]

In the previous works failures in fetching the subscriber data from the HSS are not considered. This work describes a optimized performance protocols and framework is designed to automate the performance analysis of the HSS, which is personalized for the enhanced Mobile network. The performance check includes the different robustness scenario. The framework consists of following components,

- An abstraction of workload generation and compound traffic simulation that includes the most representative services consumed in current cellular networks
- Power measurement HSS blade in the LTE network during the different load
- Performance analysis of HSS when there is interface delay in HSM and LDAP LAN by considering the different performance aspects and validating with the idle case

The paper is formulated as follows Section II briefs about the concepts on HSS and interfaces used and simulator that can be made use of for the design of this scenario, Section III briefly describes about the design and how the performance can be evaluated. Section IV gives the outline of Results along with the discussion on it Section V covers the Conclusion.

## II. BACKGROUND THEORY

### A. *Home Subscriber Server*

Home Subscriber Server(HSS) is a master user database that stores the list of service capabilities associated with the user capabilities information supports choosing a appropriate services during registration and also performs authentication and authorization of the user, supports the IMS and EPS network entity that can handle the call calls/sessions. In our work we have considered the HSS firmware contains a directory based storage of the data at the back end of HSS(BE-HSS), and the front end architecture (FE-HSS) contains a Radius protocol Handler, MAP protocol handler, Diameter protocol handler, DNS protocol handler, and the trigger interface. Radius protocol handler is the one which is used to authenticate the user to remote network. MAP (Mobile Application protocol) is an signaling system 7 (SS7/SIGTRAN) protocol which is used to authenticate the various global system of mobile communication (GSM) and universal mobile telecommunications service (UMTS) subscribers. Diameter is the authentication authorization and accounting protocol (AAA) framework for application like remote network access or IP mobility. For the reliability, security scalability and flexibility advantage, Diameter has been adopted by the 3GPP standards body as the primary signaling protocol for AAA and Mobility management in IMS. The DNS protocol is a TCP/UDP based protocol which will resolve the respective IP address into Internet names, it will convert the address in dotted decimal notation into the intuitive internet names. The SOAP (Simple object access protocol) trigger interface is located between the AAA and the backend HSS. It is used for notifying the AAA about the changes to the subscriber data and services in the BE-HSS. One trigger can contain multiple updates it can be updates to multiple subscribers or services. The back end of the HSS consists directory based storage of data, that uses the LDAP protocol to access the data when the request is received. As HSS is the center of data storage it has to authenticate the user when the authentication requests are received. This is done by the HSM box that is installed as a part of HSS, whenever needed it is converted as software authentication module by the TCP-IP connection. As an alternative to the hardware security solution. This paper mainly focuses to evaluate the optimized performance protocol in mobile data and performance of the HSS and to optimize the different scenario by automating the procedure involved in measuring the performance of the HSS which is key element causes the failure of HSS connectivity during the call connection. This not only reduces the time required to measure the performance along with this detailed summary of each scenario can be obtained.

### B. *Diameter Protocol*

Diameter is the authentication, authorization, accounting protocol which has functionalities IP and multimedia networks. Functionalities include verifying the identity of the user,



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determining weather the requesting entity is allowed to access to a resource, collection of information on resource for the purpose of capacity planning, billing or cost allocation. HSS supports diameter application such as Cx, Sh, Dx, SWx, S6a, S6d. In case if multiple HSS are present from the different vendors SLF will redirect the messages to the right HSS.

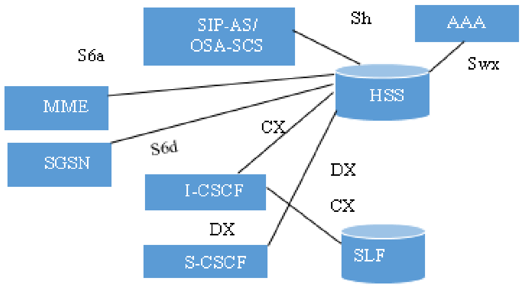


Fig. 1. Different interfaces of the LTE networks

CX Diameter over LAN interface connects the HSS to diameter client S-CSCF used to authorize a user to access the IMS , exchanging authentication information and to download and handle changes in the user data stored in the server. SH diameter interface over LAN connects HSS to AS used to download and update transparent and non-transparent user data at HSS and request and send notifications on changes on user data.

S6a/S6d diameter interface over LAN connects HSS to MME/SGSN enables the transfer of subscriber related data between the MME and the HSS.

SWx diameter interface over LAN connects HSS to 3GPP AAA server, SWx is used to authenticate and authorize the UE in EPC. This reference point is also used to update the HSS with the PDN-GW address information

### C. *Protocol simulator*

Independent protocol simulator(IPS) is a proprietary traffic generator tool, it is a script-based protocol simulator tool designed from the outset for use in either Entity or Performance testing. The main benefits of IPS are simple flow control, and it has vast set of protocols for testing either fixed or mobile networks interfaces including SIP, Diameter, HTTP, GTP-C, GTP-U RTP for voice and video call, Transports of UDP, TCP, SCTP. Independent protocol simulator is the high level language is used to describe the test cases which is independent of the protocol used and the simulator used. All the messages such as the message code, interfaces, protocol required are specified through the script and called to the simulator. The below chart represents the IPS work flow control form that it can be inferred that events are required to start the test block, there can be two types of events one can be a unexpected event other one is asynchronous event. Asynchronous event can be handled by writing the event handlers. Function wait for event specifies which event has to be executed next.

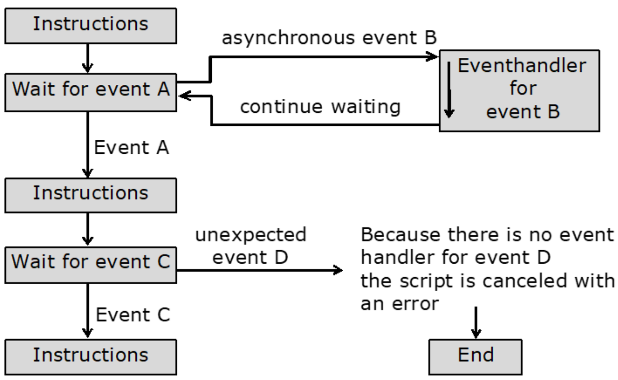


Fig. 2. Flow control of the IPS



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The internal architecture of IPS is as show in the Fig 3 IPSL script defines the definition of the message flows, IPSL interpreter will interprets the execution of the scripts statements, scenario layer will distributes the message to the dialogs and secures protocol integrity at the end of script. Lower layer will do the connection establishment and handling of connection errors. In order to run the IPS tool, at the first step depending the type of HSS firmware used load has to be pumped (in Kilo Busy Hour Call per attempt(KBHCA)) from the client machine by specifying the interfaces that are needed for the particular call flow. The different robustness scenario is tested with IPS tool and different performance aspect is validated over idle value. The IPS tool can be used in different instance in our work we have used in remote instance.

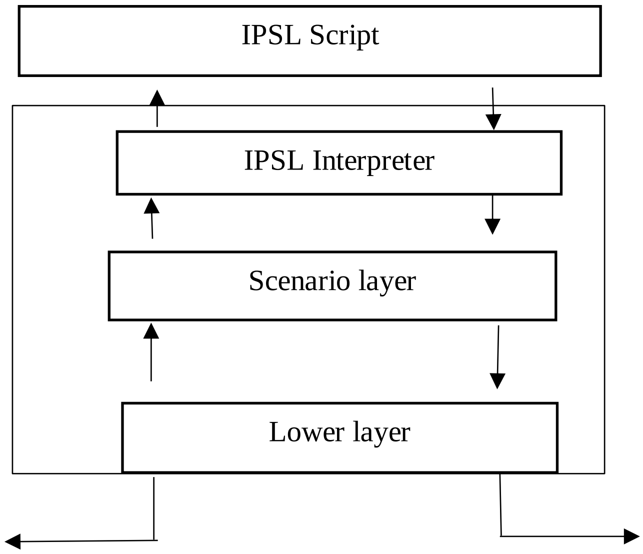


Fig. 3. Internal architecture of the IPS

## III. DESIGN

This paper focus on providing the detailed architectural framework to automate the different robustness scenario of the HSS. Robustness scenario includes the failure and network outage scenarios to validate the overload protection, recovery, resilience and reporting mechanisms of the HSS. The functional requirements to develop the framework to evaluate the performance are,

- Installation and configuration of HSS-FE
- DIAMETER via S6a/Sh/SWx/Cx/Dx
- IPSL simulator
- HSM inter working
- GUI Interface for Provisioning
- Configuration of features REST API and CM CLI
- Inter working with BE-HSS
- Inter working with NetAct (NE) via System Monitor

The framework design for the performance evaluation of HSS involves following steps,

Step1: Firstly all the configuration settings has to be scripted and those settings are dumped to the HSS node, few settings are, specification of number of interface for S6a, SWx ,Cx. SOAP trigger interface to the HLR (Home Location register) Step2: Connection to the HSM box if needed

Step3: Artificial workload has to be generated, this can be done creating the links per interfaces, in our work we have created separate links for each calls through dedicated port. Depending on the HSS firmware type load is equally divided among all the links created



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Step4: IPS(independent protocol simulator) tool has to be installed and through the independent protocol simulator language all the specification to run the IPS tool is scripted it involves different type of interfaces, protocols(Diameter, HTTP,SIP,RTP etc) also involves the different load values, external port specification etc.

Step5: Developing the script for the different robustness scenario

Step6: Through the RTP protocol all the messages are transported. By taking the dump of the RTP protocol different system performance can be grepped.

Step7: Final step is to generate the HTML report by taking the output form the IPS tool and the RTP dump

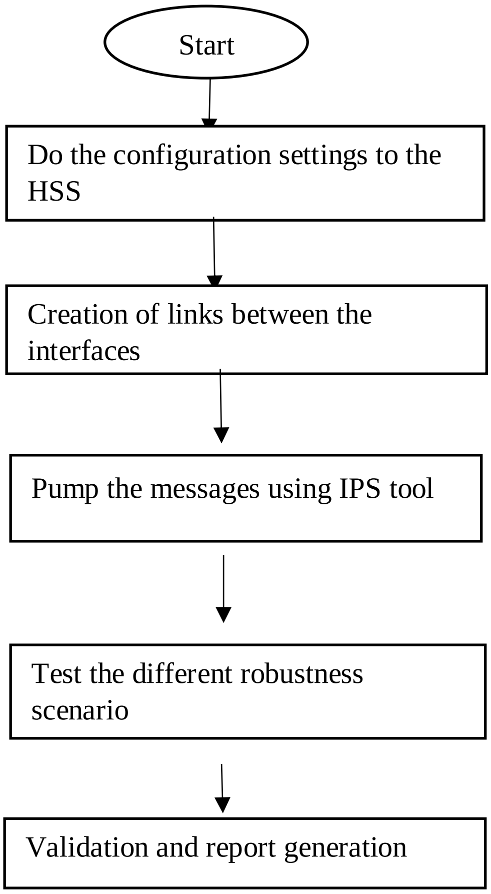


Fig 4. Flow chart of design methodology

## IV. Results and Discussion

Power is the part of QoS measurement of HSS. In a physical view, HSS consists of blades. In order to evaluate the performance of HSS, blade power plays a vital role. While considering the total functionality of the HSS blade power must be calculated. If the power consumption of blade increases than the maximum value, that may lead to unnecessary call failures. We have developed the framework to measure the power of HSS blade. To calculate the blade power ILO (integrated lights off) processor is used. This processor when configured as an on-board administrator, power can be measured at the different loads. Below graphs show the power consumption at 100%,70%,10% load.



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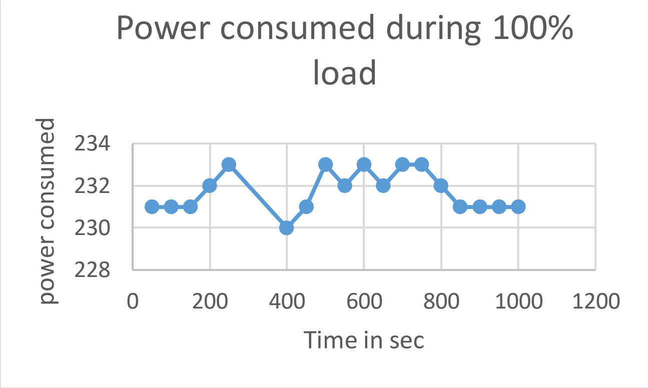


Fig. 4. HSS blade power consumption during 100% load

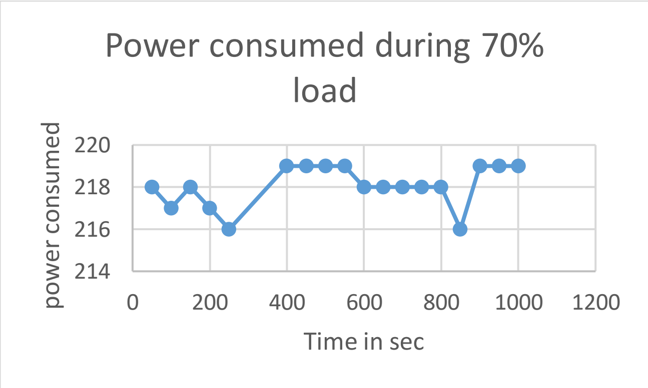


Fig. 5. HSS blade power consumption during 70% load

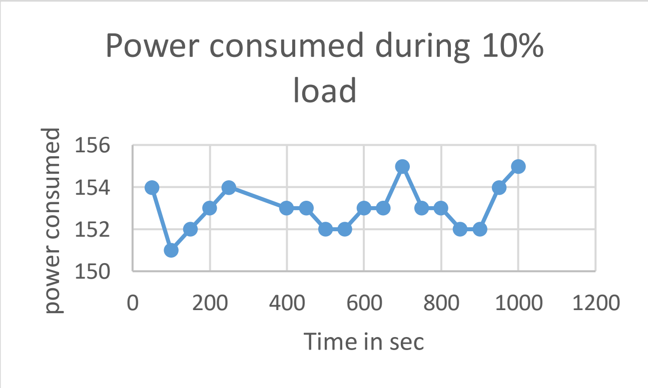


Fig. 6. HSS blade power consumption during 10% load

HSM is the box which has keys to authenticate the user. This scenario is to check the response, when there is delay in HSM LAN. We have developed the framework to check the delay in the HSM LAN. Delay is added to the HSM LAN by controlling the traffic by modifying the outbound schedular by using network emulator. Since there is delay in authentication process, few authentication calls are failing. Transaction per second(TPS) also not meeting the idle value. For CPU calculation we have considered the average of all the virtual CPU for one HSS. For the idle run CPU utilized is 88%. But with the HSM LAN delay CPU is not meeting the idle value this is because of call failures. We have simulated for 1000 sec, fig (7) shows the call failures at different times. Fig(8) shows the observation report off HSS-HSM LAN



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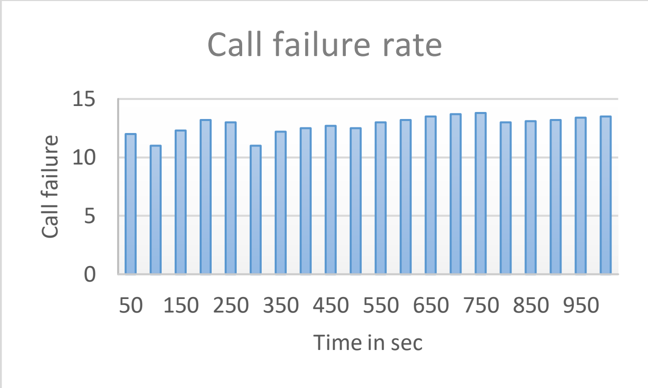


Fig. 7. Call failure rate(CFR) of HSM-Delay

| *List* | *Achieved* | *Expected* |
|---|---|---|
| **Transactions per second (TPS)** | 1200 | 1400 |
| **CPU Utilized** | 70.424 | 88 |
| **Avg CFR** | 12.79 | 0.1 |

Fig. 8. Load summary of HSS-Delay

LDAP is the interface which communicate with back end server and frontend server. When the request comes to front end server it will connects to the backend server to fetch the information required by the request. This scenario is to observe the HSS performance during the delay in LDAP LAN. Delay is added to the HSM LAN by controlling the traffic by modifying the outbound schedular by using network emulator. HSS is unable to process the call since it is unable to fetch the data on-time from the BE-HSS. In our framework we considered to validate different performance aspects like memory leaks in HSS, internal process restarts, queuing of data, overload of HSS. Since there is delay in LDAP, queueing of the data is observed. Fig (9) below shows the observation of the LDAP LAN delay.

| *List* | *Achieved* | *Expected* |
|---|---|---|
| **Transactions per second (TPS)** | 254.077 | 1400 |
| **CPU Utilized** | 39.537 | 88 |
| **Avg CFR** | 48.974 | 0.1 |

**Load summary**

- **No process restarts observed**
- **No memory leaks observed**
- **queues observed**
- **No system overload observed**



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Fig. 9. Load summary of LDAP-Delay

## V. CONCLUSION

In this work, we have considered the possible failures in the real time HSS which is not being considered in any previous works and we have deigned a framework to test the HSS with those possible failures. System performance with those failures are detected and summarized. The framework we have developed is platform independent it can be reused to any kind of failure detection of HSS. The results observed are in the real time scenario we can understand how 3GPP in telecommunication is vital for the release and as well as the evaluation of Public network that is the Internet and other data network are also required which is taken care during the HSS bring up. This framework has the wide coverage performance aspects of network monitoring which is not being observed in any previous work.

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