Virtual SIMs – the Future of Telephony as a Service

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Abstract

Mobile Computing is a persuasive computing paradigm which has been incorporated in our daily lives. Mobility in communication has become a necessity and a way of life for both B2B and M2M applications due to the hype of online advertising in social networks and mobile VoIP apps. Although smartphones are limited to processing, memory and power capacity, their advent has made it possible to touch the world with one click, anywhere and anytime. The Global System for Mobile Communications (GSM) model brought about unimaginable revolution to the telecommunication industry and built a profound architecture for most Next Generation Networks (NGN) technology. However, the SIM card technology requirements on various mobile devices and networks is distinct from GSM to CDMA to UTMS but why not provide a universally accessible and standardized virtual SIM as a service offered on demand on the cloud? Additionally, the process of SIM activation varies from one region to another; this is incapacitating at times for diverse Communication Service Provider (CSP) subscribers. This research will seek to design and analyze the architecture for SIM card virtualization being adopted into the Communication as a Service (CaaS) in a Cloud platform and provide Telephony as a Service (TaaS). The virtualization platform will seek to provide multiple virtual SIMs on demand and accessible on any mobile device or browser. Analysis of the GSM SIM card architecture and proposed technology will be drawn while recommendations are envisioned. The key technologies to be used include Web services, Android and Twilio APIs.

Keywords:

Mobile computing, SIM card virtualization, virtual SIM, Communication as a Service, Twilio APIs, Telephony as a Service.

1. Introduction

Mobile Computing describes the ability of a movable device to process or perform a task while getting network connection. Something which once seemed impossible in the fixed network has been revamped by the new paradigm of mobility promoting access to network services anyplace, anytime, and anywhere. Mobile devices are the driving force to most business nowadays which have become the new WebTop for most enterprises (Gotora, T.T.,, Zvarevashe, K. & Nandan, P., 2014, Xiaoyi Chen, 2011) The ordinary citizens have adopted the smartphone culture of wanting uninterrupted access to social networking sites and a variety of other tele services from their Communication Service Providers (CSPs).Most African countries have recorded tremendous growth in mobile clientele especially the Southern Africa with Zimbabwe having a 500% growth over the past 5 years while Nigeria and South Africa being elevated to global powerhouses. Data services have taken a larger part of the revenue with traditionally calling and SMS services being subsidiaries. VoIP applications and free text platforms seem to be exponentially growing and so is the demand for an elastic and scalable network infrastructure. Most CSPs are heavily impacted by congestion tremors and have multiple complaints to deal with from unsatisfied users.

The advent of Cloud Computing has stimulated CSPs ambitions to provide Communication as a Service (CaaS) in most IT developed countries. This is due to the growing user needs in processing, storage and power consumption thus offering these as a service could prove vital in improving user satisfaction. Quite a lot of smartphone virtualization techniques have been proposed in Xiaoyi Chen, 2011. And while the Web's evolution to 2.0 opens unlimited communication potential. Most smart phones require various SIM card technologies used in different networks for instance SIM (for GSM), USIM (for UTMS) and CSIM (for CDMA). There are also distinct size requirements in different mobile devices namely a regular SIM measures 15 mm x 25 mm and micro SIM or 3FF(Third Form Factor) SIM card is 12mm x 15mm. At times it inconveniences users entering a new country to gain access to these from sellers due to the many document requirements and delayed activation time. Over the years web services have evolved into more than just mere integration communication methodology to powerful real-time integration web hooks and has improved from the tougher SOAP syntax to simple REST. Also improvements from Session Initiation Protocol (SIP) to Web Service Initiation Protocol (WIP) all fostered in CaaS as highlighted in Gotora, T.T. Kudakwashe Zvarevashe, K. &Pranav Nandan, P.. (2014). This research seeks to adopt a design architecture for SIM virtualization which will be implemented on android devices while applying Twilio RESTful APIs via a Twilio cloud. The paper will be composed of 6 categories. Section 2 will look at analysis of the current GSM architecture and various SIM virtualization solutions in play. Consequently section 3 goes to exam the design architecture of proposed virtualization technology and section 4 brings out the implementation results. The comparison of virtual SIM and GSM SIM comes in section 5. Finally the conclusion and recommendation sums it up in section 6 and 7 respectively.

2. GSM Architecture and SIM Virtualization Solutions

2.1 GSM Architecture

The current GSM mobile communication uses a Subscriber Identity Module (SIM) Schiller, J. (2008) to uniquely identify a mobile subscriber and for authentication purposes. This is physically inserted into a mobile device/station. It enables the Mobile Station (MS) to connect to the GSM network. As shown in Figure 1, the MS is located at the Base Station Subsystem (BSS) cell and connects to the Base Transceiver Station (BTS) via the U_m interface. When the MS connects to the BTS, the SIM saves a temporary mobile (dynamic) cipher key for encryption, temporary mobile subscriber identity (TMSI), and location area identification (LAI) obtained from MSC and kept at the Visitor Location Register (VLR) Database. VLR is responsible to act as the foreign agent who copies mobile user data from Home Location Register (HLR) while updating Location Area (LA) of user.

The international mobile subscriber identity (IMSI), card serial number and type does not change when the MS moves into another location which is stored on SIM. Each SIM has a PIN (personal identification number) which causes one MS unlocking when establishing connection to another MS. Every SIM has a PUK (PIN unblocking key) which enables the subscriber to unlock it if accidentally locked due to some reason and stores a 128-bit authentication key provided by the service provider. Authentication is processed by MS via a Mobile Switching Centre (MSC) through an algorithm using this key and a 128-bit random number dynamically sent by Authentication Centre (AuC). If the MS is not authenticated, the service to that number is blocked.

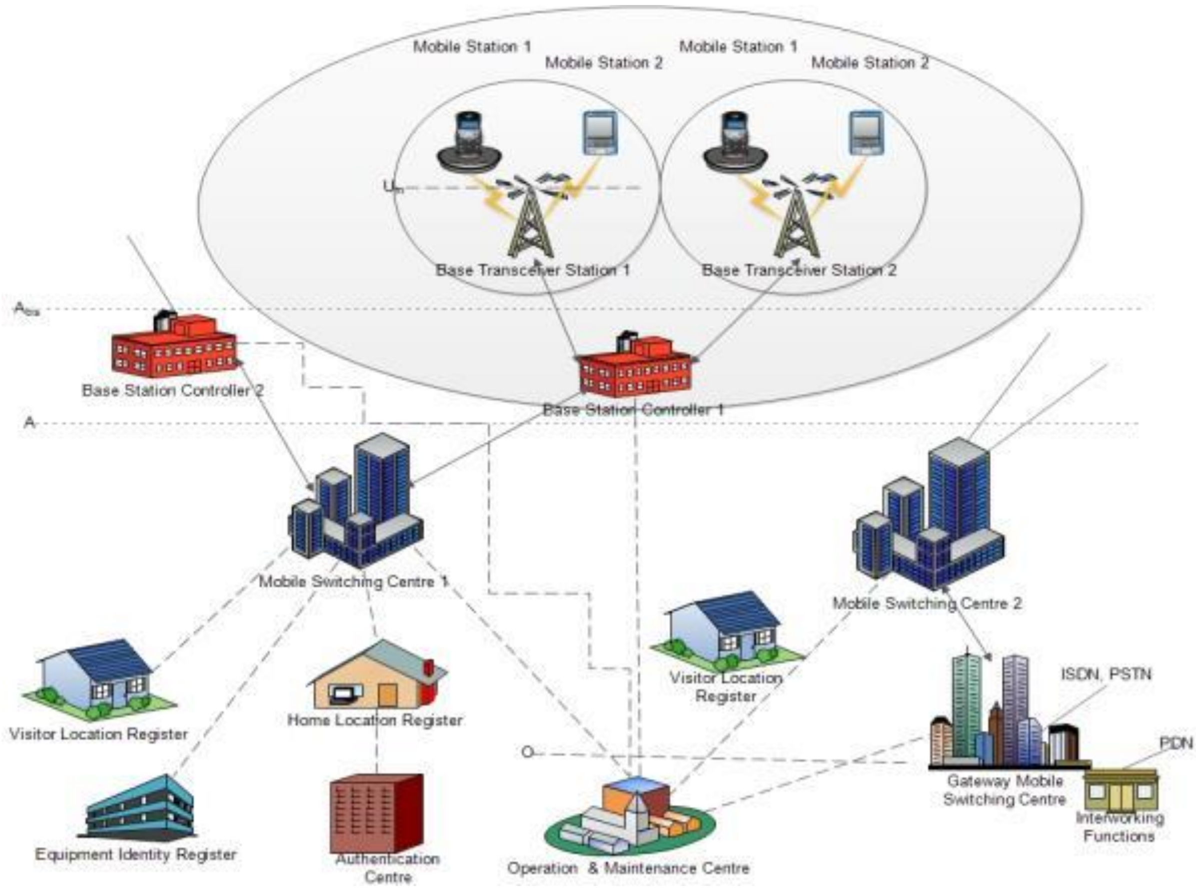

Figure 1: GSM Architecture

2.1.1 Advantages of GSM Architecture (Schiller, J.,2008)

- GSM uses a hierarchy of 3 subsystems (RSS, NSS and OSS) which enable management of mobile subscribers easily.
- Supports various tele services like telephony, SMS, emergency number, MMS and call forwarding to mention just a few.
- GSM is supported by a plethora of telecommunication networks (e.g. PSTN, ISDN,

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and PDN) and protocols.

- Use of SIM secret information, AuC and VLR enforces better security for user confidentiality and identification.
- Supports both data and voice transmission.
- SIM is unique to a subscriber and can be attached to any GSM-enabled phone.
- Supports roaming services in global mobile networks while making use of VLR attached to the MSC.
- Supports GPRS (General packet radio services) which is fully internet oriented.

2.1.2 Disadvantages of GSM Architecture

- Subscriber requires multiple SIM cards or mobile devices for different tele services [4].
- Current user demands surpass the GSM availability and traffic limits.
- If SIM is hacked, user identification is compromised.
- If SIM PIN and PUK are lost or forgotten it would be impossible to use a blocked SIM.
- GSM is connection-oriented thus requires additional frameworks like GPRS and High Speed Circuit Switching Data (HSCPD) to cater for the data traffic [3].
- Operational costs of GSM model is high and expensive to expand.
- Expensive roaming charges.

2.2 Current SIM Card Acquisition and Activation Process

Buying a SIM card in India is usually carried out at a mobile dealer store or via street vendors or at the CSP and some documents are handed in which include the personal identification, passport size photos, residential proof and registration form. While in Zimbabwe they require a national identification document and activation happens in 24 hours. The vendors will then take the registration forms in batches to the CSP centers to be verified and if applicants meet the standards their SIM card is activated, else modification is requested as shown in Figure 2. Each time a user requires a SIM they have to physically go through this process and mostly there are delays in activating services to the potential subscriber. Some ignorant or less informed foreigners usually get duped by vendors by being sold stolen or unauthorized SIMs on the streets. This destroys clientele trust and is detrimental to the CSPs reputation.

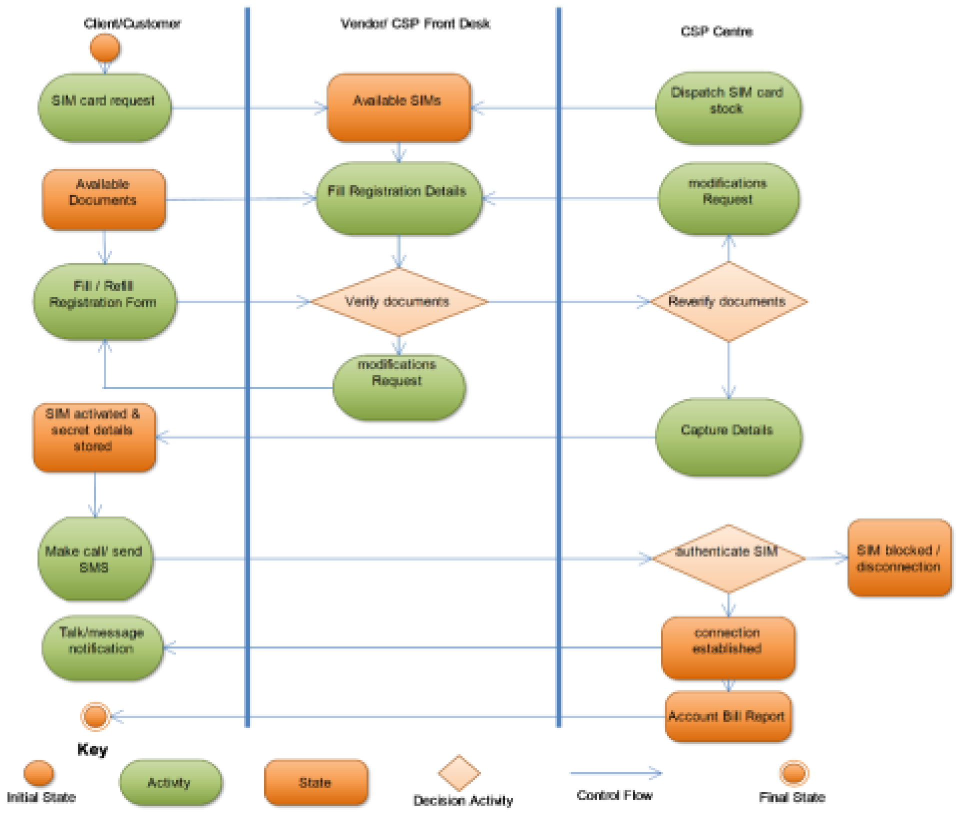

Figure 2: Current SIM Card Activation Process

Most business personnel require multiple phones and SIMs to cater for their daily business operations which at times is cumbersome to carry around. To try to solve this issue most mobile device manufacturers introduced the dual SIM technology which has proven to be helpful as it can accommodate two CSP services. However when a client moves from one region or country to another they have to experience exorbitant roaming charges to use their respective telephone lines which is rather unrealistic to the general public. Justifications have been raised by the various service providers and telecom regulators, but in this modern era of technology where the cloud and web services are viable isn't there another solution?

2.3 Movirtu Virtual SIM Solutions

"Omnia mutantur, nos et mutamur in illis" said Nicholas Borbonius (16th Century). *As the telecommunication industry is trying to expand its soft infrastructure to meet the increase in user demands in tele services while reducing capital expenses (CAPEX), new solutions have risen. Movirtu ManyMe solution (*Movirtu, 2014a) *is a virtual SIM service which allows a subscriber to use multiple mobile numbers on one device, as it's based on the Movirtu's patented SIM virtual platform and viable within the standard mobile networks. This is an initiative which is meant to solve the issue of having to swap between multiple SIMs and or devices to use different CSP services. It is independent of the SIM operator which will be physically placed in a mobile device.* ManyMe supports both feature phones via USSD and smartphones with a user friendly app. Users can add or remove additional mobile numbers from within the app and instantly use new numbers for making and receiving calls. *Telecom giants like Airtel have seen the future of telephony leaning towards virtual SIMs hence it*

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*recently launched a group-wide partnership with Movirtu in June 2014(*Movirtu, 2014b) *As of date Airtel Africa has rolled out the Movirtu Share service in Madagascar and DRC, which offers business enterprises with virtual SIMs at reasonable costs and reducing communication infrastructure costs. These solutions have many pros to both the user and mobile operators. The different mobile operator clients enjoy the service of distinct providers without having to buy other handsets/SIM cards. The various CSPs benefit from gaining extra customers and less operational costs as the expansion is provided using software integration. However this software is still expensive to purchase for upcoming service providers and it could prove exorbitant to manage for most government institutions.*

2.4 Implementa Virtual SIM Platform

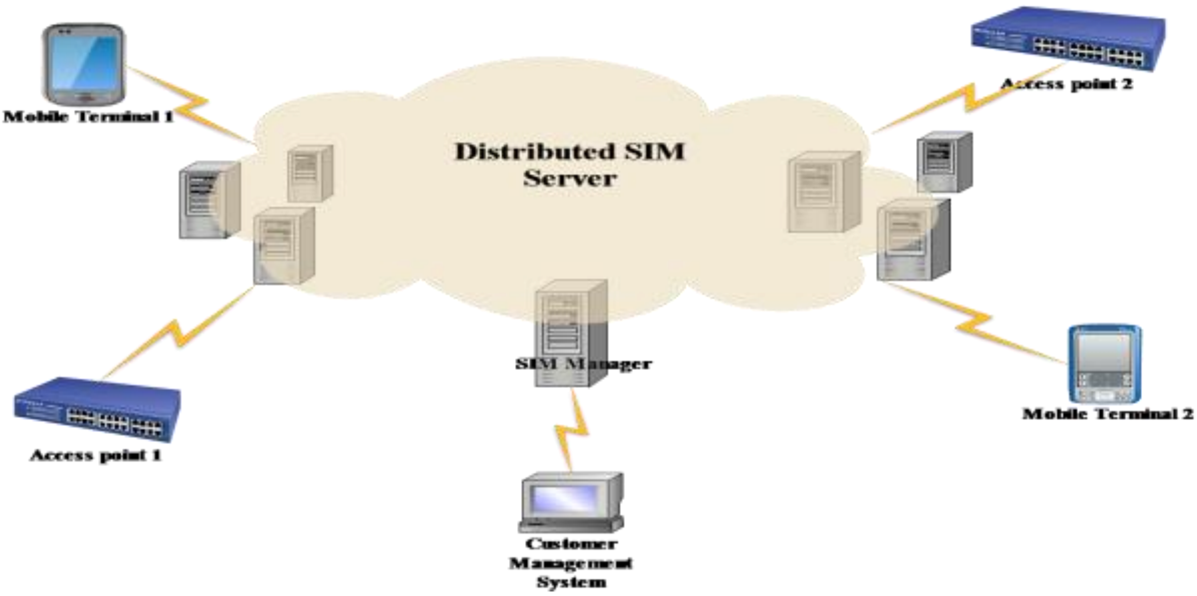

Figure 3: Implementa Virtual SIM Platform Architecture [8]

Implementa is also a modern day corporation which offers many virtual SIM solutions, having one of its objectives as not re-inventing the wheel. Implementa virtual SIM platform Implementa. (2014) provides allocation and usage of virtual SIMs from a mobile terminal (MT) without physically inserting a SIM card. There exists a remote SIM storage which manages the physical SIMs and keeps track of them. The platform makes use of an OS and language independent API which facilities easier integration with various customer apps and devices. The clients can perform normal voice calls and messaging functions. The virtual SIM platform architecture is integrated into the standard mobile network as shown in Figure 3 above.

2.5 Apple's Soft SIM

Apple for a long time has been talking of the virtual SIM concept and the new iPad TelcoReview.(2014) Hill, S.(2014) recently launched in October 2014 by Apple provides a soft SIM feature. Allowing users to select from a limited range of provided CSPs from a menu and still accommodates the use of physical SIMs. The soft SIM is a feature which comes at a time when the hype of doing away with physical SIM cards is at bay in the telecommunication industry. It will provide a client with a user-driven facility to dynamically use different network operators in a loosely coupled manner and with short term plans of usage /release in a pay as go manner. However this forces most customers to purchase expensive Apple products and having to stick to the only provided CSPs. A lot of demands are left unmet like what if the client wants to access the services of a mobile operator not listed in the Apple menu and wants to take their contract number with them or has to sell their old phone.

2.6 Simgo Virtual SIM Platform

Simgo (2014) is one of the world's first CSPs to offer virtual SIM solutions for smartphones with a motto to reduce roaming costs while exhibiting profound identity security, which is a key concern to the mobile user. Also providing broadband global M2M and amplified operational competence. Simgo Virtual SIM Platform makes possible the separation of SIM card from mobile device like the Implementa Platform while making use of a cloud server storing a plethora of SIMs. A remote device which acts as the SIM card holder can be a smartphone cover, a self-contained module or a low power, 9x9mm chip to be integrated into equipment with cellular modules. Drawbacks of this solution are the additional costs of the remote device and the poor network connection in remote areas.

3. Proposed Design Architecture of SIM Card Virtulization

The proposed virtual SIM technology will adopt the features of previously discussed technologies in Movirtu. (2014a, b) Implements, (2014 TelcoReview. (2014) [9] (Simgo, 2014) [12] and will seek to improve on the weaknesses highlighted, although in the long term due to the limitations in technology and research time. The proposed design architecture will allow the possibility of multiple SIMs being accessible from one Mobile Station like the other virtual SIM solutions. It will be implemented using Android SD platform, Twilio Cloud and Web Services which include; using Restful APIs, TwiML, PHP and Java. All the technologies are open source except access to the Twilio Cloud tele-services. (Monica, R., Dinesha H.A, & V.K. Agrawal., 2013), (www.twilio.comThe Virtualization process will follow 3-tier architecture as depicted below in Figure 4.

The Client, MS1 which is the mobile phone will have a SIM card initially for authentication purposes. It makes a request to the web server which then connects to the Cloud Server via Restful API to obtain the required client account details while authenticating client request. Once ascertained a token is generated at the web server and sent back to Client with virtual SIM details based on the CSP selected. This can be stored at mobile device or kept at web server only after user has acknowledged. The virtual SIM will consist of the client name, IMSI, session ID and the authentication token. If client is valid the subscriber number can be used to make calls or send SMS/MMS just like in an ordinary GSM network. The only difference is that the virtual SIM connects to the server via an internet connection first before a request is redirected to the desired destination. This will promote faster processing of MS requests and the less memory usage on the phone. Call forwarding, redirecting and recording should be also possible. A subscriber can be given an option to use as many virtual SIMs (vSims) as they deem to meet their needs. Thus a user can buy by selecting mobile numbers and can release them at any time as they wish in a pay as you go mode. This will promote scalability and cheap operational costs to both CSPs and clients. The system should also provide a flexible integration mechanism with other traditional public networks like GSM, PSTN, PDN and modern UMTS.

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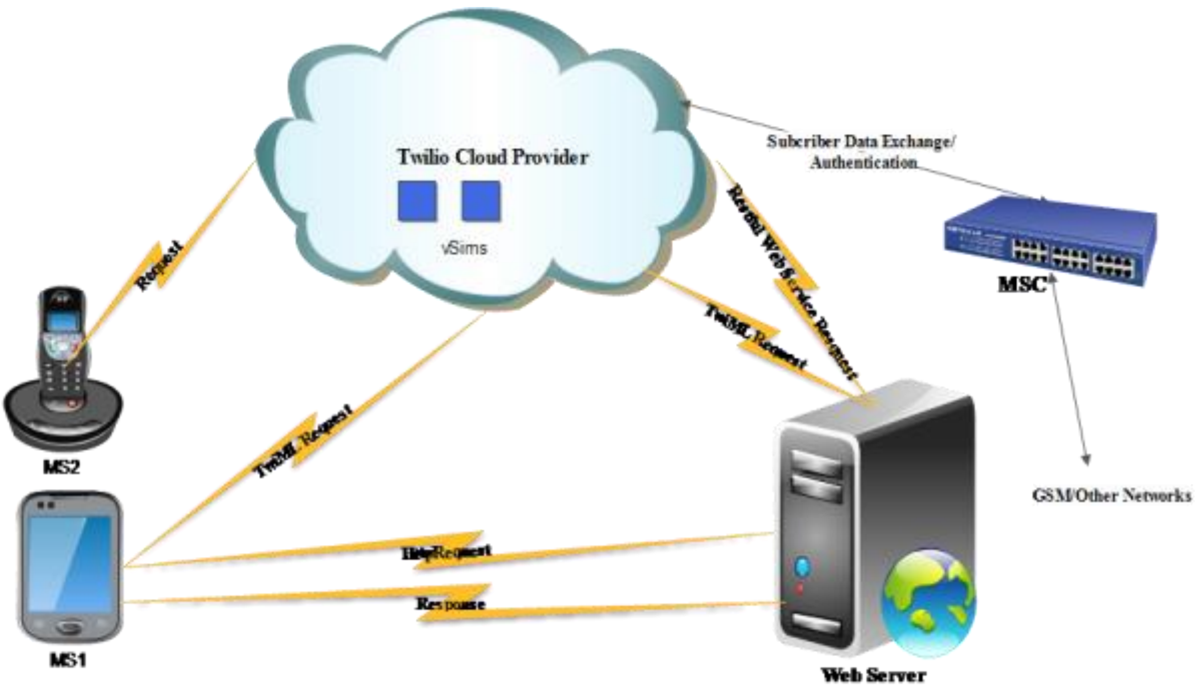

Figure4: Proposed Design Architecture www.twilio.com.docs

3.1 Advantages of Proposed System

- Offer multiple SIMs to one client.
- Offer a notification or alert system to client in case client is busy on another call.
- Uses simple traditional http request and methods to perform telephony services.
- Easy to implement and expand via the Cloud services.
- Client can buy and release vSims at will while only paying for required services.
- If SIM details are lost they can be recovered and all logs can be obtained from cloud.
- Can be integrated into existing system and interoperable with other networks.

3.2 Disadvantages of Proposed System

- Restricted to network connection (Wi-Fi or LAN) as it needs access to Internet to connect to cloud or web server.
- Security is dependent on third parties trust and the user community does not have full trust on cloud security.
- VoIP applications usually exhibit unreliable and slower voice transmission.

4. Implementation of the Proposed SIM Card Virtualization Technology

The implementation process was tailored to follow the overall design architecture of the proposed system while making use of reusable software components. An Android mobile app will act as the Front-End, while the Back-End will be the server side app. The Twilio Service Provider will act as the Middleware as it handles requests or caters for services from client to server and vice versa. The app will consist of a main menu, registration part, call and messaging module. As a major pre-requisite to able to use the Twilio services (www.twilio.com) the researcher had to register on the Twilio site and deposit a certain amount electronically into the created account to be able to have full resource catered. This encompassed buying a virtual number and registering a verification mobile number, which was an Indian Airtel number. Consequently the development process required an open mind and time.

4.1 Algorithm for Main Module

Step 1: Enter login /register details.

Step 2: Validate details, if invalid go to step 3

Step 3: Renter login details

Step 4: Connect to server via Asynchronous task and verify details

Step 5: Error message if invalid else step 6

Step 6: Select Call /Message service

Step 7: Perform Call /Message service

4.2 Call Module Implementation

The call module was first implemented using a combination of android and Twilio-android client APIs. A number of tests were carried out but after sometime a disconnection error problem was encountered and as a mitigation measure Twilio-java sdk had to be put in place of the Twilio-android client API, although this didn't have a user-friendly interface. With the server side code implemented in PHP and Twilio PHP helper libraries, which make the necessary REST API calls to the Cloud. As a prerequisite, a voice URL (Monica, R., Dinesha H.A, &V.K.Agrawal, 2013) had to be configured in the established Twilio account linking to a TwiML (similar to XML although uses Twilio defined verbs) application written on web server.

Using Twilio-android client APIs	**Using Twilio java SDK**
Step 1: Initialize Twilio Device Listener object Step 2: Make http request to server to obtain capability token Step 3: Show error message if invalid request else Step 4 Step 4: Return capability token Step 5: Create Twilio Soft Device Step 6: Enter phone number Step 7: Validate number according to E.164 standard Step 8: Initiate call to destination number Step 9: Leave message or end call	Step 1: Create a new Twilio REST Client object Step 2: Make REST API call Step 3: Authenticate the client account and authentication token Step 4: Return account details else Step 5 Step 5: Print Invalid message else proceed to Step 6 Step 6: Make Call REST API Step 7: Pass call parameters Step 8: Validate parameters. Step 9: Initiate call to destination number Step 10: Print success or failure message.

Table 1: Make Call Implementation Algorithms

4.3 Messaging Module Implementation

The messaging module was implemented using Twilio-java sdk and java libraries although this didn't have a user-friendly interface. There was also a new telecommunication regulations introduced in India like the National Do Not Call Registry which restricted promotional messaging thus limited messaging from 9am-9pm.

4.3.1 *Sending Message Implementation Algorithm [5]*

Step 1: Create a new Twilio REST Client object

Step 2: Make REST API call

Step 3: Authenticate the client account and authentication token

Step 4: Return account details else Step 5

Step 5: Print Invalid message else proceed to Step 6

Step 6: Call Message REST API

Step 7: Pass message parameters

Step 8: Validate parameters.

Step 9: Send message

Step 10: Print success or failure message.

4.4 Testing Results

The best success stories in any innovation have to undergo failure and as per norm expectations in the implementation process quite a number of shortfalls rose but the testing process gathered quite a number of lessons.

4.4.1 Call Module Unit Testing

The developer carried out a number of tests some which include functional tests on the validity of a number on the client side. If an unverified number was entered when making a call the exception message appeared is as shown in Figure 5 and to rectify the issue the developer had to add the number in the Twilio Main account using an E.164 approved format as noted in the Twilio documentation (Monica, R., Dinesha H.A, & V.K. Agrawal, 2013). Figure 6 shows the call status graph from February-September 2014.

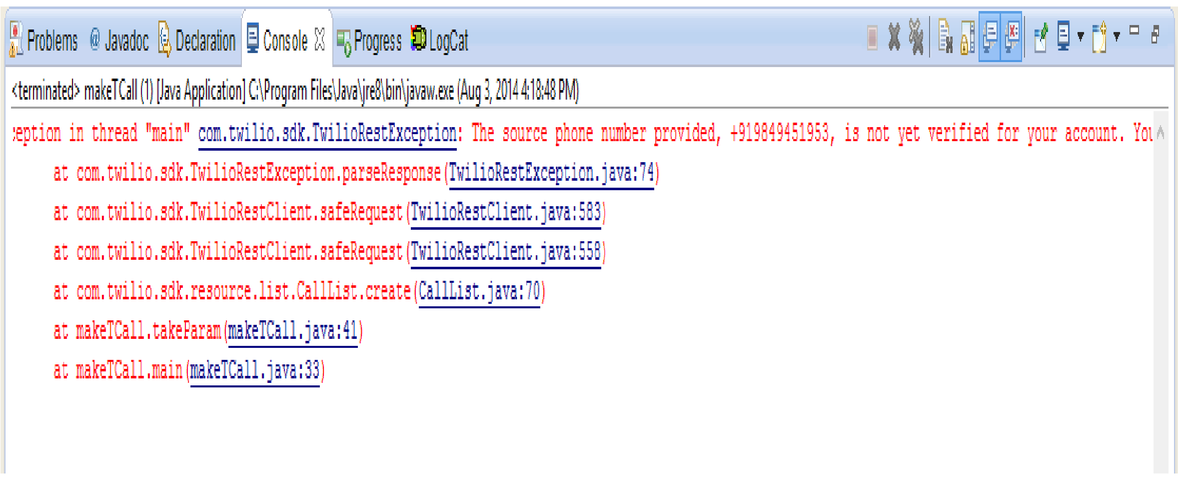

Figure 5: Invalid Number Exception in java SDK environment

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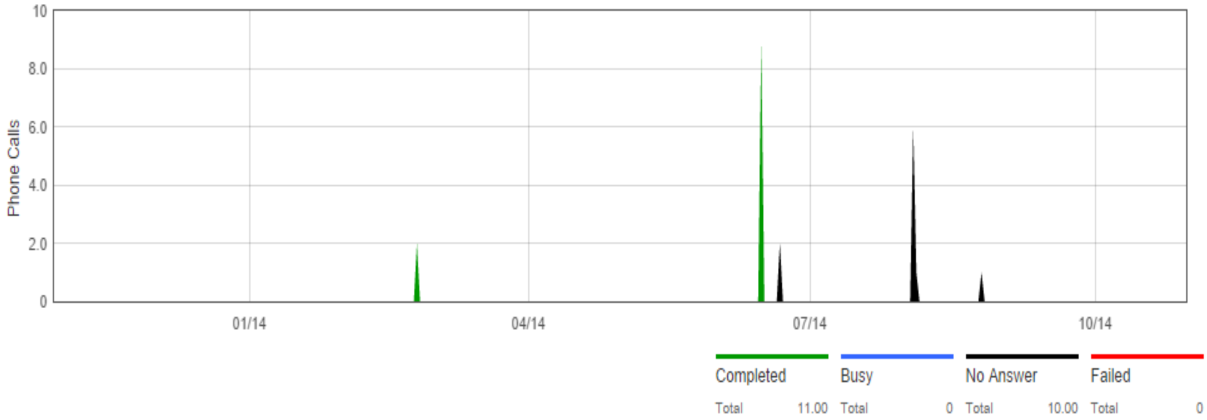

Figure 6: Call Status Graph from January-September 2014

4.4.2 Message Status Report

A status progress graph for the messages sent and received can be obtained from the Cloud server and the user can keep a track of their usage in a clear manner. Although there is no implicit function to show the delivery of a message on the android platform it still is possible to use REST API /TwiML verbs to show this.

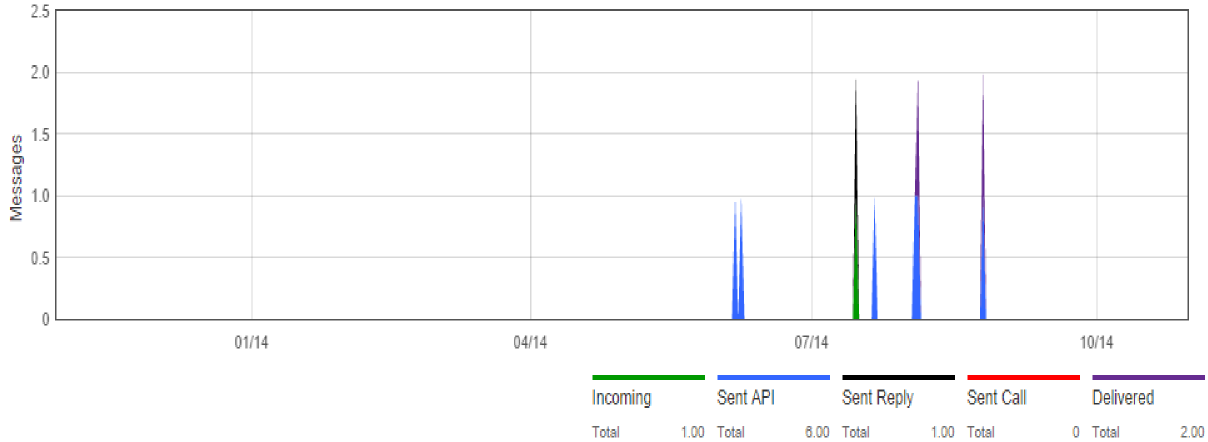

Figure 7: Sent & Received Messages Status Graph from January – September 2014

5. Comparison of GSM SIMs and Virtual SIMs

GSM SIM card	Virtual SIM (vSIM)
Speed of call connection request is between 300-400ms depends on network congestion	Speed of call connection is between 300-400ms
Can use 2G, 3G and 4G facilities	Require Internet access like Wi-Fi
Roaming charges are expensive	Roaming charges are cheaper
Messages can be sent any time depending on network congestion. Rate of sending is many at a time from one mobile number.	Messaging timing services between 9am-9pm in India but anytime outside. Rate of sending is one at a time from one mobile number.

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One SIM for each phone	Multi SIMs for each phone
Longer purchasing process sometimes huge delays like one week.	Easy purchasing process which can be done in a few minutes at the comfort of one's home online.
Security check is faster as the SIM card already stores the authentication key and TMSI.	Security checking process is slower as there is double checking at the web server and at the cloud center.
Tele services reports for each client take time to extract.	Easy for client to monitor their own tele service usage with graphical representation.
Conference calls not supported fully	Conference calls can be supported fully
If SIM card is lost data retrieval process takes time depends on the CSP.	vSIM can be released and bought again while data retrieval is faster.
Uses up phone memory to store SIM details	Uses up less memory on phone while more SIM data is stored on a cloud.
Can be implemented on GSM enabled phones	Is implementable on all android devices and extendable to the browser and iOS phones.

Table 2: Comparison of GSM and virtual SIMs

6. Conclusion

"Camel trips do not begin or end, they merely change form", said Robyn Davidson. Likewise in carrying out an investigation which seeks to transform and enhance a traditional way of communication the journey from the requirements gathering to implementation has taken many twist and turns. Initially when the research started, the concept of SIM card virtualization seemed impossible and far-fetched. The current GSM communication model is a stronghold in the telecommunication industry and has survived the test of time. Its robust connection-oriented paradigm has been evolving over time due to the technological advances like the Web 2.0, the cloud and the overwhelming smartphone user demand. The cloud is here to stay and is the future hence adopting communication as a service is a must for most Communication service providers and this will promote a pay as you use mode.

The researcher adopted a SIM card virtualization architecture based on Monica, R., Dinesha H.A, &.Agrawal, V.K. (2013) research on Phone Call as a Service and Twilio a cloud service provider integrates these various technologies to offer a multipurpose telephony platform. The architecture consisted of 3-tiers; the Web server, client and the Cloud which acts as the Middleware and Back End. Thus the researcher chose this platform as a means to achieving his objectives. The research was a success as the concept of virtual SIMs was proven by the ability to buy Twilio numbers online and use them to make the ordinary tele services like making a call and messaging. The security aspect is still under scrutiny and comparison of the two models GSM and Web-based CaaS during the whole project shows there are smaller differences in communication speeds but more user satisfied needs with the former model.

7. Recommendations and Future Works

There is need for more analysis and experimentation with the various Open APIs being offered by companies like Twilio, Google and Pub Nub so as to build complex real time telecommunication applications. The Twilio APIs needs to be fully exploited so that some problems like compatibility with higher version of Android and Windows can be reduced. For future works the researcher will seek to integrate and apply his project discoveries into educational and business real time scenarios. While doing an in-depth analysis of the virtual SIM performance and add more features using the available APIs. There is also need for more research on fully virtualizing the smartphone on the cloud in asynchronous real time distributed environments while integrating with the growing Software Defined Networks.

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