

Modeling an IVR System using GPRS enabled devices and AT Commands

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Abstract-IVR Systems has become more than a necessity these days for all type of organizations. Every organisation despite of its nature of work needs IVR System. IVR System plays an integral role in automation of various processes with human interaction and gives a feel to caller as if caller is interacting with a human being and not a machine and thus gives better customer experience in all type of organizations like a company, an education organization, a hospital, a Bank. Without IVR System neither of these can survive. An IVR System consist of many technology and components like Speech Synthesizer, Speech Recognition, DTMF encoder and decoder, database and Hardware upon which entire system operates and thus in general has huge cost involved for installation as well as maintenance. Organizations need to purchase costly hardware and need to pay high cost of operation even if need of organizations are very limited. In this paper we are going to purpose an IVR System that could be modelled using AT commands in a multi module software system which is connected to a simple GPRS enabled device say a normal GPRS enabled mobile phone. We will also discuss different layers and integration of these layers in proposed software system.

Keywords: IVR System, DTMF, Speech Synthesizer, Private Automatic Branch Exchange, Audio Response Unit, VoiceXML, TTS, ASR, GPRS enabled devices, GPRS enabled Mobile Phone, AT Commands.

I. INTRODUCTION

IVR System [1] is a technology that makes interaction between human being and Computer as if there are two human beings interacting. An IVR System masks a Computer or Computing device and present itself as if that is a human being. IVR allows

customers to interact with a company's host system via a telephone keypad or by speech recognition, after which they can service their own inquiries by following the IVR dialogue. IVR systems can respond with pre-recorded or dynamically generated audio to further direct users on how to proceed. IVR applications can be used to control almost any function where the interface can be broken down into a series of simple interactions. IVR systems deployed in the network are sized to handle large call volumes.

This is a common need of IVR System in all organization. Whether it's a company or a university or a college or a hospital or a bank or a call centre. Without IVR System no business can sustain.

For a company IVR System is required for attending its client as IVR serves as Automated Attendant. A university or college typically use IVR System for dealing with students queries, a hospital need IVR System as attendant for patients and care takers. Call centres use IVR System for both answering customers as well as for calling customers for marketing and sells purpose. Banks now a days has a feature of Phone Banking and IVR System is what making that successful.

Some of the benefits of an IVR System are:

- Enables automation of processes.
- Improve customer service.
- Lower implementation cost.
- Service with chosen language
- Call logs available for auditing, performance report and future enhancement.
- Provide 24*7 availability for customers.
- Provides secure interaction between computer and human being and thus secure business like banking or account management becomes

possible.

- Out bound dial gives a great customer experience in marketing campaigns.
- Call Centre and BPOs are there just because of IVR Systems

II. IVR SYSTEM MODEL - REVIEW

HISTORY

[1] To understand architecture and implementation of conventional IVR System a study of telephony system is prerequisite.

The first telephones were connected directly with each other by cable. As this technology continued evolving, the necessity of finding a more scalable solution arose. One centralized system uses n instead of $n*(n-1)$ connections between n participants. This enormous reduction led to the invention of an electronic circuit system called **Telephone Exchange** or **Telephone Switch**. Such a switched system began to play the role of telephone the connecting part between two or more telephony end points. Later it was called **Exchange** the **Central Office**. Every telephone set is connected to the central office by a pair of cables, defining this way the so called **Local Loop**. At the beginning the destination number was sent by dial pulses as a result of measuring how far the rotary dial is, before being released.

At the beginning the destination number was sent by dial pulses as a result of measuring how far the rotary dial is, before being released. Nowadays, this method is replaced by sending a sequence of touch-tones, known as **Dual-Tone Multi Frequency (DTMF)**.

For simplification purposes, the architecture of a phone system adopted later concepts like **trunking** which can be explained as a tree structure with a main transmission channel (**The Trunk**) beginning from the switch centre and branching at the opposite end into smaller lines. The amount of all possible telephone exchanges forms the so called **Public Switched Telephone Network (PSTN)**.

The granularity of the telephone structure can be further refined with the introduction of so called **Private Branch Exchange (PBX)** or **Private**

Automatic Branch Exchange (PABX). It plays the connecting part between a private telephone network of an organization and the PSTN. With the extremely fast development of the Internet in the 1990's, this concept evolved to **VoIP PBX (Voice over Internet Protocol)**. VoIP describes a technology that allows delivery of voice signals through a packet-switched network (usually Internet) able to communicate with other networks through the **Internet Protocol (IP)**. VoIP is often referred to as **Internet Telephony** or **Voice over Broadband (VoBB)**.

IVR SYSTEM ARCHITECTURE

A typical IVR application consist of an IVR System exposed over PSTN and connected to Application Server which is connected to database system.



Figure 1:A Typical IVR System

A caller want to know information related to his account could call on customer care number from mobile phone or landline phone. Call would be routed to specified number through PSTN. An IVR System is hosted at called number along with PABX which would then play a pre-recorded welcome message using Pre-recorded Audio Player and would either route the call to available line or would ask caller to wait, on getting an available line it would then transfer call to attendee or may ask user to input more choices. Choices would be decoded by DTMF Decoder so that IVR System can understand and act upon. Then these provided user choice would be processed by IVR System. IVR System then request application server to fetch or calculate details based on input choice. Application server using database would generate response and send back to IVR System. IVR System then synthesis speech using Speech Synthesizer for the response returned by

Application Server. The IVR System would then play the same to caller (Explained in Figure 1).

IVR SYSTEM COMPONENTS

Entire IVR System can be understood as multiple layers which perform designated tasks. Figure 1 explains basic functioning and data flow of IVR System, figure 2 presents detailed layered architecture of components of IVR System:



Figure 2: A Layered Architecture of IVR System

Automatic Call Forwarding

This is typically task of PABX or PBX to land the caller call to available line. It lands the call to lines based on predefined algorithm and if all lines are busy IVR may play a message stating “All our representatives are busy, please hold on.” PABX is most important component of the IVR System as this enhance the system to serve multiple users at a time.

Telephony Interface

The Telephony Interface are APIs, which provide computer telephony integration and enables PC to use telephone services. Different implementation and versions of these APIs are available that allows applications to control telephony functions between a computer and telephone network for data, fax, and voice calls. It includes basic functions, such as dialling, answering, and hanging up a call.

Automatic Speech Recognition (ASR)

ASR is used for building speech-driven user interfaces and provides an efficient and intuitive spoken alternative to touch-tone (DTMF) applications.

DTMF Decoder

This is either a software component or a hardware component depending on the implementation of IVR System that decoded input of the caller based on touch-tone or button pressed. In modern IVR Systems these are typically software components. DTMF was originally decoded by tuned filter banks but in modern world *Digital Signal Processing* became the predominant technology for decoding. DTMF decoding algorithms often use the *Goertzel Algorithm* to detect tones.

DTMF keypad frequencies (with sound clips)

	1209Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

DTMF Generator

Like DTMF Decoders DTMF Generators are also can be Software or Hardware components based on implementation of IVR System. In modern IVR Systems these are typically software components that

generates DTMF tones and that can be given back as response to caller. This are a required feature in case caller wanted to integrate response with some other IVR or Voice Command System.

Speech Synthesizer

An IVR system communicates in human voice so a component is required that synthesize human voice. The text-to-speech (TTS) unit is responsible for transforming an input text into TTS an audio file. TTS engines are often referred to as speech synthesizers.

Pre-recorded Audio Player

Despite of many researches and developments in Speech Synthesizer still human voice is better than synthesised voice. Therefore every IVR System has some pre-recorded messages that it plays while interacting with caller. Only data part is in general synthesised and that is concatenated to pre-recorded message. The components that plays these messages is known as Pre-recorded Audio Player and is commonly a software components.

Multilingual Support Engine

There are cases when callers calling at customer care, belongs to different region and languages and thus an IVR System must support multiple languages. The software component that enables IVR System to support multiple languages is Multilingual Support Engine.

VoiceXML

VoiceXML (VXML) is a digital document standard for specifying interactive media and voice dialogs between humans and computers. It is used for developing audio and voice response applications, such as banking systems and automated customer service portals.

IVR Request-Response Tree

A typical IVR System presents choice to a caller and on the basis of choice provided either it would serve the response or would again present choices. This is in general a configurable part in any IVR System and typically looks like Figure 3.

Application Server

This is a separate machine or server which is responsible for doing all processing on data. In some implementation this server is connected with HTTP Server and several web applications are hosted on these. This server can be used for catering reporting need or can provide another channel as web application for IVR System.

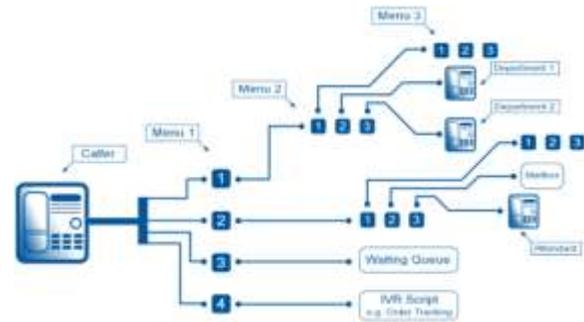


Figure 3: IVR System Request-Response Tree

Database Server

This is typically a Relational Database server or LDAP Server which is used for storing all the data of all the customers that could be asked by caller. Information about all the inbound and outbound calls, call duration and other information's of call are also stored in database and may be used for reporting purpose. In some cases report engines are also implemented.

III. MODELING A NEW IVR SYSTEM

As studied above an IVR System is a big multi-module system. It involves some hardware components as well which makes IVR System costly and thus takes it away from reach of small company or organization. Organizations need to pay huge cost for installation and maintenance of it which is a significant amount.

We are proposing a new IVR System which is mainly software based, easy to configure, install and use. What all you need to make that operation is:

1. GPRS Enabled Mobile Phone/Data Card
 2. A Computer
 3. Proposed IVR Software
 4. A simple Audio Attenuation Cable
2. Get the current status of the mobile phone or GSM/GPRS modem. For example, mobile phone activity status (AT+CPAS), mobile network registration status (AT+CREG), radio signal strength (AT+CSQ), battery charge level and battery charging status (AT+CBC).

UNDERLYING TECHNOLOGIES OF PROPOSED MODEL

Before this model is explained a study of all the technologies that makes proposed IVR System feasible is required.

AT Commands

AT commands are instructions used to control a modem. AT is the abbreviation of ATtention. Every command line starts with "AT" or "at". That's why modem commands are called AT commands. Many of the commands that are used to control wired dial-up modems, such as ATD (Dial), ATA (Answer), ATH (Hook control) and ATO (Return to online data state), are also supported by GSM/GPRS modems and mobile phones. Besides this common AT command set, GSM/GPRS modems and mobile phones support an AT command set that is specific to the GSM technology, which includes SMS-related commands like AT+CMGS (Send SMS message), AT+CMSS (Send SMS message from storage), AT+CMGL (List SMS messages) and AT+CMGR (Read SMS messages). Starting "AT" is the prefix that informs the modem about the start of a command line. It is not part of the AT command name. For example, D is the actual AT command name in ATD and +CMGS is the actual AT command name in AT+CMGS. However, some books and web sites use them interchangeably as the name of an AT command.

Here are some of the tasks that can be done using AT commands with a GSM/GPRS modem or mobile phone:

1. Get basic information about the mobile phone or GSM/GPRS modem. For example, name of manufacturer (AT+CGMI), model number (AT+CGMM), IMEI number (International Mobile Equipment Identity) (AT+CGSN) and software version (AT+CGMR).

3. Establish a data connection or voice connection to a remote modem (ATD, ATA, etc).
4. Send (AT+CMGS, AT+CMSS), read (AT+CMGR, AT+CMGL), write (AT+CMGW) or delete (AT+CMGD) SMS messages and obtain notifications of newly received SMS messages (AT+CNMI).

There are two types of AT commands: *Basic commands* and *Extended commands*.

Basic commands are AT commands that do not start with "+". For example, D (Dial), A (Answer), H (Hook control) and O (Return to online data state) are basic commands.

Extended commands are AT commands that start with "+". All GSM AT commands are extended commands. For example, +CMGS (Send SMS message), +CMSS (Send SMS message from storage), +CMGL (List SMS messages) and +CMGR (Read SMS messages) are extended commands.

GPRS Enabled Devices

Every IVR System has a unit that is responsible for taking and dialling calls. In this model it is a GSM GPRS enabled device like a GPRS enabled **Mobile Phone** or a **Data Card**. Generalising these as **GPRS Enabled Device**. Since these devices has a flexibility of being controlled by AT Commands, thus a software implementing AT Command can control these devices. Every smart phone that we see today is a GSM GPRS mobile phone and thus can be used in proposed IVR System. Cost of these mobile phones or data card is significantly less than any standard IVR System.

PROPOSED IVRS SOFTWARE

The heart of proposed model of IVR System is its IVRS Software. Which has all the components of an

IVR System within it as different software modules. Figure 4 explains different modules of it.

IVRS Software has 5 different modules in it which are corresponding to standard modules of any IVR System.

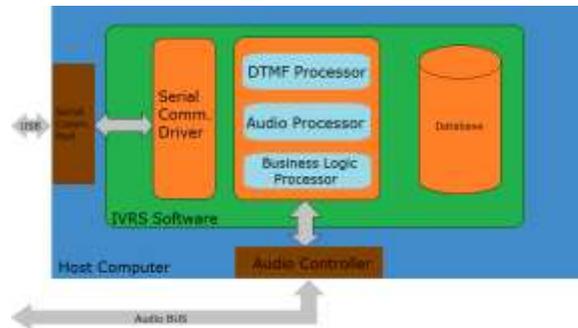


Figure 4: Proposed IVRS Software Architecture

Serial Communication Driver

This module enables communication between Host Computer and GPRS device connected at COM port so that IVR Software can send and receive AT commands from GPRS device. This software usually depend on the make and model of mobile phone or data card.

DTMF Processor

This module is a combination of both DTMF Decoder and DTMF Generator. It recognise input based on key pressed similar to traditional IVR System and generator DTMF tone whenever required. This is purely a software component.

Audio Processor

This software module is responsible for all the audio related stuff. It has an Automated Speech Recognition Unit for recognising voice commands, TTS (Text to Speech) System for converting textual data in to voice and a Pre-recorded Audio Player that plays the pre-recorded audio files for giving a touch of real time human voice.

Business Logic Processor

This software module takes care of all the business flows that are automated or supported by IVR system. This module is similar to Application Server module in traditional IVR Systems. This module is highly configurable to cater all needs of users.

Database Server

Like traditional IVR System this is also a Relational Database server or LDAP Server which is used for storing all the data of all the customers that could be asked by caller. Information about all the inbound and outbound calls, call duration and other information's of call are also stored in database and may be used for reporting purpose. In some cases report engines are also implemented.

Universal Serial Bus (USB)

Universal Serial Bus, is an industry standard developed in the mid-1990s that defines the cables, connectors and communications protocols used in a bus for connection, communication, and power supply between computers and electronic devices like keyboards, pointing devices, digital cameras, printers, mobile phone, data card, portable media players, disk drives and network adapters.

Audio Bus

Audio Bus provides an audio route between GPRS Enabled Device and Host Computer. It connects audio output of GPRS Enabled Device to audio input of Host Computer and audio output of Host Computer to audio input of GPRS Enabled Device.

COMPONENTS OF PROPOSED IVR SYSTEM

The proposed IVR System constitutes of Host Computer, GPRS Enabled device (say Mobile Phone), USB cable, Audio Bus Cable and IVR Software.

Host Computer

Host Computer is the system on which IVR Software is installed. GPRS enabled device is connected to this computer at COM port via USB cable and Audio input/output is connected at Audio Bus via Audio Bus Cable. As shown by Figure 6. This computer do all the computations of IVR System.

GPRS Enabled Device

This is the communicating unit responsible for making voice calls. The IVR software commands this device for making or answering any call. This could be a simple mobile phone or data card.

USB Cable

A simple USB cable is used to connect GPRS device with Host Computer at COM port.

Audio Bus Cable

This cable is responsible to transmit Audio Output of GPRS device in to Host Computer (so that IVR Software can process that) and Audio Output of Host Computer to GPRS device (so that this can be sent over call). Audio Bus cable looks like Figure 5.

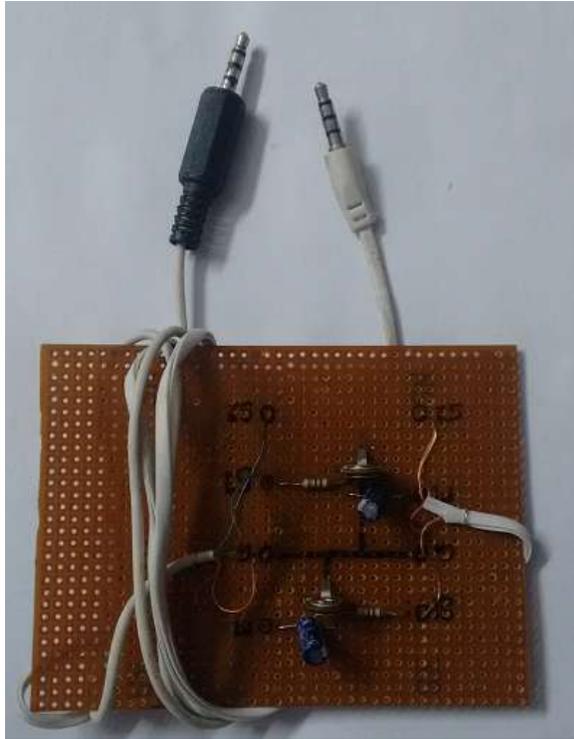


Figure 5: Audio Bus Cable

IVRS Software

This is responsible for overall processing and putting bits together in to a working system.

COMPLETE WORKING MODEL



Figure 6: Proposed IVRS Software Architecture

When user call at MSISDN of GPRS Enabled Device, call is received by IVRS Software (using AT Command), and Audio is feed to IVRS Software through Audio Bus. Then IVRS Software plays the instruction on the basic of Business Logic Processor and data stored in database using Audio Processor. User input as DTMF signal is decoded by DTMF Processor and according response if provided to user similar to traditional IVR System.

IV. CONCLUSION

In this paper we figured out importance of IVR System as this is one of the most important breaks through in the field of telecommunication and software engineering. IVR System provide a voice response to the customers and guide them to the information they require anywhere and anytime. The customers can call up any institute such as banks, universities, tourism industry and obtain any information by simply pressing certain button on his telephone as per the guidance of the voice fed into the computer. IVR System is an electronic device through which information is available related to any topic. IVR System is usually employed to know more about the organizations and can be modified to respond to voice of the customer for better response customer satisfaction. IVR System can be employed in customer services there by improving its flexibility and efficiency.

Problem with traditional IVR System is high installation cost and even high operational cost. Users need a huge amount even if they need just a single line.

The proposed IVR System is really very cost effective and easy to install. Users can have its setup in their own computers or servers.

This system is simply composed of an IVRS Software, a GPRS Enabled Device and an Audio Bus Cable. This system is highly effective, flexible and scalable. This solution makes IVR System so affordable to users that they can use that facility at cost of mobile phone.

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