End to End Automation and Testing for STB(Set top Box) and Docsis Cable Modem with Escape Defect Analysis

Submitted By

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Thesis

Submitted in partial fulfillment of the requirements

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Submitted By

Anukruti Arya

(15MCEN02)

Guided By

Prof. Malaram Kumhar

DEPARTMENT OF INFORMATION TECHNOLOGY

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Certificate

This is to certify that the Thesis entitled **"End to End Automation and Testing for STB(Set top Box) and Docsis Cable Modem with Escape Defect Analysis"** submitted by **Anukruti Arya (Roll No: 15MCEN02)**, towards the partial fulfillment of the requirements for the award of degree of Master of Technology in Computer Science and Engineering(Network Technologies) of Nirma University, Ahmedabad, is the record of work carried out by her under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this Thesis, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Abstract

Set top Boxes are devices which helps in displaying the transmitted content onto the TV. Each STB requires special bin and iips files to function properly and desirably. This process can be carried out using the process Campaign Creation.

Automation is the connecting of different or dissimilar systems or software in a manner that they behave as self-regulating entities. Usually this is done so that mundane tasks can be done more efficiently and effectively , thus cutting labour time. Mundane task automation has a benefit that it would do redundant task in lesser time than humans, thus reducing time of doing the task and at the same time human intelligence and time can be used for some other useful tasks. Campaign Creation is a process of configuring the STB that has been automated so that it can be done in lesser time than humans take, thus reducing time of doing the task.

Escape defect analysis, also known as EDA is a process of detecting whether or not an escape has occurred , after testing of the product to be released was done. If an escape is found, it's root cause analysis(RCA) takes place, which is done by development or the testing team to determine the actual reason of its occurrence and after analysis, the problem is assigned to the respective individual(also known as assignees) or team of individuals for elucidation process.After the issue is resolved, its plan of actions are retrospected so that same action can be used to solve an issue of similar kind in future. In the nutshell, Escape Defect Analysis involves finding the effectiveness of phase detection. Development and Test team would identify why the specific issue was introduced and identify the action items to prevent it in future.

Data Over Cable Service Interface Specification or DOCSIS is an international standards for Cable modems that will provide data stream to Cable TV etc. These standards are normally used to achieve high speed and QOS for the services they provide.

Abbreviations

STB	Set Top Box.
EDA	Escape Defect Analysis.
RCA	Root Cause Analysis.
JIRA	Jira Testing Software
DOCSIS	Data Over Cable Service Interface Specification
CMTS	Cable Modem Terminal System
CM	Cable Modem

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Chapter 1

Introduction

Arris Group is an American telecommunications equipment manufacturing company that provides cable operators with high-speed data, video and telephony systems for homes and businesses.[4] The company has design, engineering, manufacturing, distribution, service and sales office locations throughout the world.[4]

1.1 Existing senario

Arris grew its presence in Set-top market with the acquisition of Motorola Mobility. Since then it has been serving several clients in the same sector. Arris Group has various sectors like Networks, Cables , and Set-top boxes but Arris India is mainly involved in testing of Set-top boxes to ensure top quality STBs are delivered to the clients. Testing in Arris is carried out in on various features of the STBs. To carry out testing, boxes should be loaded with proper builds. These builds comprises of two components

- Platform Configuration Files
- Application Configuration Files

To load these components into the boxes, the process of campaign creation is carried out. Configuration files are not understood by the hardware of STBs individually. To do so, the configuration files should be in a particular format. This is done when a package is created with all the necessary Application Configuration Files and respective Platform Configuration File. This package is then loaded into the box. Now the testing of the box can be carried out.

My work at Arris can be mainly categorized into 2 categories:

- System Automation and Testing
- Tool Development and Enhancement.

1.2 System Automation and Testing

Automation is the connecting of different or dissimilar systems or software in a manner that they behave as self-regulating entities. Usually this is done so that mundane tasks can be done more efficiently and effectively , thus cutting labour time.
Mundane task automation has a benefit that it would do redundant task in lesser time than humans, thus reducing time of doing the task and at the same time human intelligence and time can be used for some other useful tasks.

1.2.1 Campaign Creation

A campaign is a set of objects targeted to a specific set-top type bundled together with metadata. The campaign will include code objects and additionally include data objects.

1.2.2 Sikuli

Sikuli is an GUI automation tool used for automating Campaign Creation Process.

1.2.3 Testing of STB working

This process is carried out when the box is loaded with the proper build and is ready to be tested. Various functionalities of STBs are tested and based on the results, the Quality of the box is improved . Also based on testing results various defects, scope of improvements and positive or negative conclusions are determined.

1.3 Tool Development and Enhancement

This category mainly focuses on tool development for testing of STBs. Tool named AutoMOTO is used by Arris India to carry out a variety of tests for Product Quality Assurance.

1.3.1 Escape Defect Analysis Tool Overview

EDA is a tool which is used to find the Root Cause of any defect which was detected during the testing phase. After RCA, the issue is addressed with the proposed solution.

1.3.2 DOCSIS Firmware Up / Down grade process Automation

It is a process of automating the mundane and manual task of firmware Up / Down grade. A single Firmware can take anything from 1 minute to 1 hour to upgrade for a single device. This tool up/down grades the firmwares and returns a summary report indicating the time taken for each process and if the procedure from one image to another was a success or failure. It mainly uses SNMP , TFTP / HTTP protocols and Python as the scripting language.

Chapter 2

Literature Survey

2.1 Set top box

STB is a device that converts a digital television signal to analogue for viewing on a conventional set, or that enables cable or satellite television to be viewed.[5]

2.1.1 How does a Set-top box works?

- Set top box, or STB consists of a tuner, which can decode the broadcasted signals into such a format that can be understood byt the box and in turn casted onto the television.
- These can carry out functions that normally cannot be carried out by a TV
- Most ordinary of them being inability of tuning into satellite broadcasts and cable TV broadcasts.
- All STBs usually operate on subscriptions basis. Some content is payed and some can be viewed for free.
- All the paid content is in an encrypted form so as to avoid in unauthorized viewing of data.These stbs after getting the payment information , decrypts the content and thus displays onto the TV.
- Other Functionalities available on a STB are TV Guide, Video-on-Demand, Games,Live streaming etc.

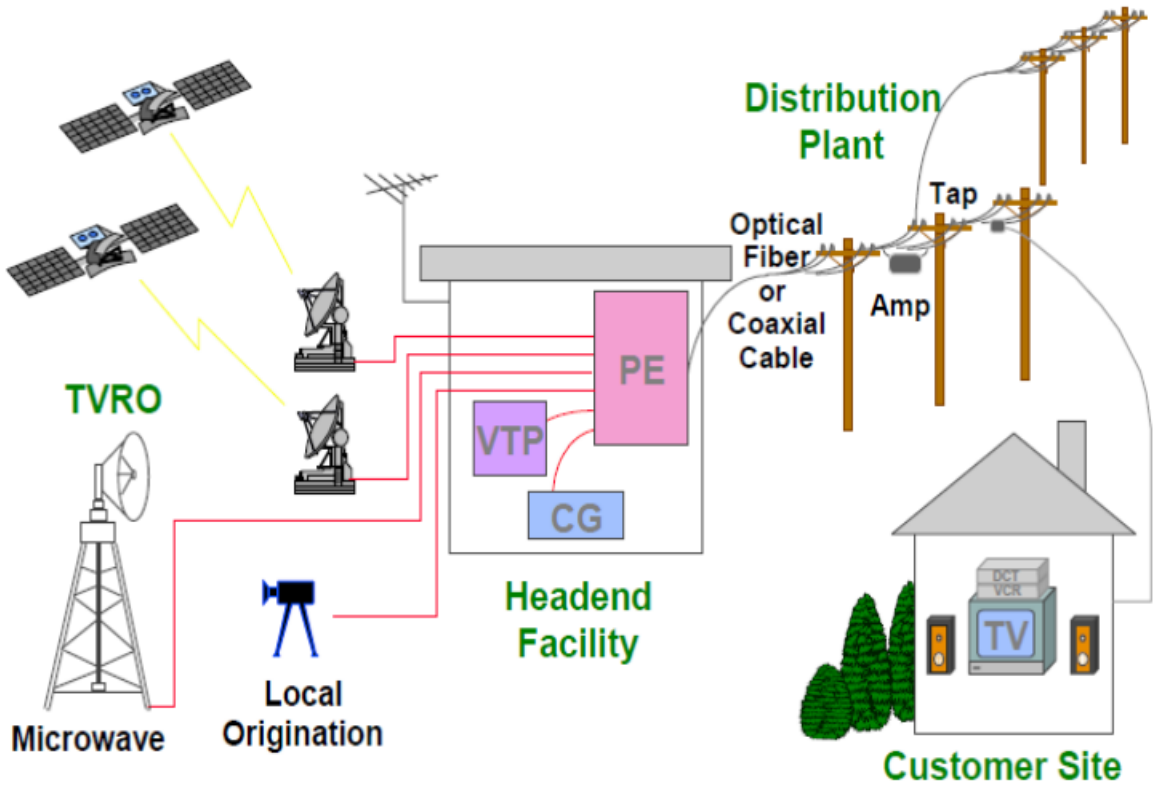

Figure 2.1: STB Broadcasting System

2.1.2 Standard: Digital Television Broadcast Systems (DTBS)

It is the broadcast system that transmits audio and video by digitally processing and multiplexing signals. Digital TV is capable of supporting more than one program in the same channel bandwidth and supports MPEG videos. Various standards followed in DTBS are

- ATSC (Advanced Television Systems Committee): North America, Canada, Mexico, South Korea etc.
  - Used by Terrestrial and Cable delivery systems
  - Bandwidth of single channel 6MHz
- DVB (Digital Video Broadcasting): Europe, Australia and New Zealand etc.
  - Coded orthogonal frequency-division multiplexing (OFDM) modulation
  - Supports hierarchical transmission.
- DMB (Digital Multimedia Broadcasting): China (including Hong Kong Macau).

  - Follows Radio transmission technology for in transmission of multimedia over TV, radio etc.
  - Also supports datacasting to mobile devices such as mobile phones, laptops and GPS navigation systems

- ISDB (Integrated Services Digital Broadcasting): Japan, Philippines etc.
  - Uses of OFDM and two-dimensional interleaving.
  - Also supports hierarchical transmission of signals of up to three layers.
  - Used mainly in MPEG-2 video and Advanced Audio Coding.

2.2 DHTMLx Suite

The DHTMLX suite (or dhtmlxSuite) is a JavaScript GUI widget library for building dynamic web applications with desktop-like user experience and Ajax data loading.[6]The modular architecture of the library allows using the components separately or combining them into one JavaScript file.[6]

2.2.1 Features of DHTMLx Suite

- **Desktop like UI experience**: The suite gives a UI feel like a desktop, like drag and drop, editing of code. This makes working with the suite easier.
- **Client-Server Communication**: Client-Server communication in the suite is similar to usual C-S communication. So the users don't have to do anything extra for setting up a Client-Server communication.
- **Visual Designing of the Components**:The Visual Designer allows user to design the web components without actually coding. A live form of the same is also available.
- **Themeing support**: A wide variety of themes are supported so that users can a variety in their UIs.
- **Cross-platform and Mobile device support**: supports cross-platforming . Also projects designed in dhtmlx are compatible with Mobile devices like Android, Windows Phones etc

2.2.2 UI Components in DHTMLx Suite

Various UI components available in DHTMLx Suite for designing are

1. DataGrid
2. Layout
3. Forms
4. Charts
5. Windows
6. Calender
7. Containers etc

2.3 DOCSIS

Data Over Cable Service Interface Specification or DOCSIS is a telecom standard, first introduced by CableLabs and is used to provide Internet access via a cable modem. It is used by ARRIS Group for Cable TV or CATV, Modems, DSL etc. Various components used in developing the automation of firmware up / down grade of Docsis modem are as follows.

2.3.1 SNMP

SNMP is a network management protocol, which has 3 basic entites

- Device to be managed
- SNMP Agent, and
- Management Unit / System

2.3.2 MIB

MIB is a structural view of a virtually existing database of network entities or devices that are being managed.

2.4 Techniques

Based on the requirement of the project various techniques were used so as to maintain the progress of the work. Various languages like Python(scripting) , C, Javascript, XML(Parsing data and scripting) were used during the project. Various concepts like

- Retrieving names of campaigns from XML using Regular expression in python as a part of campaign creation process.
- Choosing required iip from the list of iips using XML parsing and pattern matching in python for campaign creation process.
- Downloading the canvas using html2canvas.js in EDA tool enhancements.
- Grouping of various filter names used under one name so as to avoid redundancy and ambiguity in EDA tool enhancements.
- Sending mail as a reminder for pending action of tasks assigned to a particular assignee in EDA tool enhancements.
- Learning DHTMLx as a part of EDA tool enhancements.
- Understanding DOCSIS standard for Firmaware up/ down grade process
- Understanding basic architecture of the Docsis cable modems used by Arris
- Getting familiar with SNMP, TFTP and HTTP protocols and the manual procedure of firmware up/down grade.
- Understanding the erroneous conditions or situations that may leave modem in an inconsistent state , thus indicating failure of the procedure.

Chapter 3

Campaign Creation

3.1 Overview of Casmr/Cast and Campaign Creation Process

3.1.1 What is CASMR/GIL?

CASMR is a conditional access system. It consists of a modular framework in which software plugins can be added to provide new functionality. Various components and functionalities of CASMR include

1. Code objects
2. repository
3. User-friendly interface to deploy campaigns.
4. Multiple campaigns deployment using group ID (multicast/unicast)
5. MRL signaling file to download code objects (not required to understand).

3.1.2 What is Cast?

CAST, also known as CASMR Configuration Assistant is a server which is used to upload code objects of required build on the server to make it available for use and to create campaigns which can be used to Deploy so as to make them operational or functional for STB's use. GIL(depicted in figure 3.1)

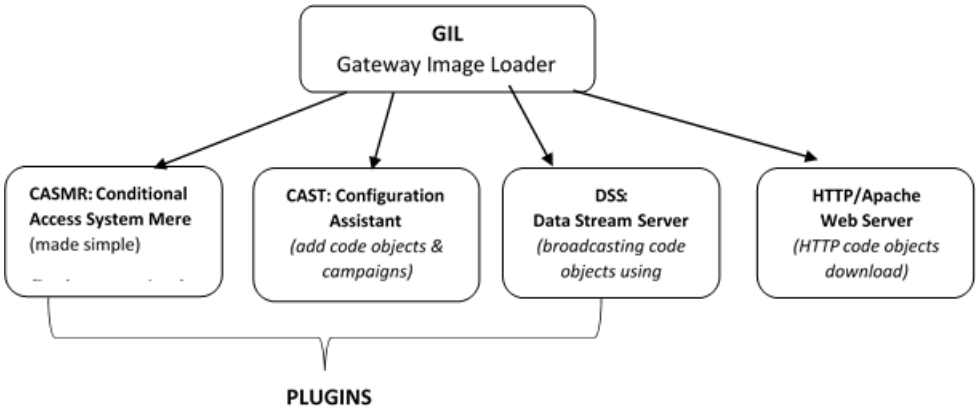

Figure 3.1: GIL overview

3.1.3 What is a Code Object?

Code object is a binary file used to configure a particular functionality of the STB. For example, UI ,Audio,Video,Applications etc are all functionalities of a STB and so all will have a dedicated binary file for their functionining. File extention of a Code Object is **.iip**

3.1.4 What is a Campaign?

A campaign is a set of objects targeted to a specific set-top type bundled together with metadata. The campaign will include code objects and additionally include data objects.

figure 3.2 shows the relation between IIPs(Application Configuration files) and BIN(Platform Configuration File):

Campaign Creation Steps :-

1. **Adding Code Objects**: First process done in campaign creation. These Code objects are used to specify the download type of the IIPs the STB of the particular user requires. Campaign is always determined by the Code objects.

2. **Adding Campaign**: Process followed after the code object is created is adding a Campaign in which the Code objects are used. Various steps

   - Campaign Identification
   - Target Model Selection
   - Code Object Selection

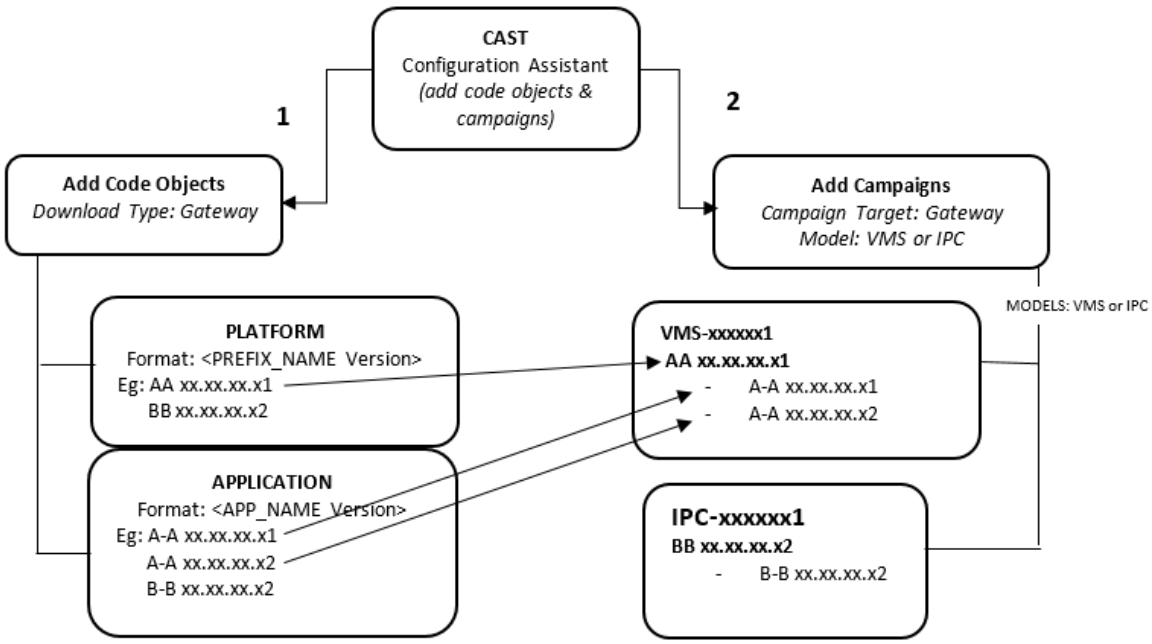

Figure 3.2: Campaign Creation Relational Diagram

3. **Deploying a campaign**: Process of deploying the added campaigns, so that they can be used further.

3.1.5 Issues in campaign creation:

1. Platform Issues:

   - The issues related to Platform download, Platform Installation.
   - Display of incorrect information Code download Module(Like Code download status, Installation status, May and Must time display).
   - Reboot on KIT upgrade.
   - Authentication bypass.
   - NTP could not set time to the box.
   - Loosing of SSL and DTCP keys.
   - Front panel download icon.

2. Application Issues:

   - Generally issues which are on UI/application side i.e., Mandatory software update banner
   - May/Must time Notification issues

3.2 Sikuli IDE

3.2.1 What is Sikuli?

Sikuli is an open-source research project. This is a visual technology to automate and test graphical user interfaces (GUI) using images (screenshots).It basically means Automate anything you see. It includes

1. Sikuli Script
2. Visual scripting API for Jython
3. Sikuli IDE.

SikuliX is a Java application, which works on Windows XP+, Mac 10.6+ and most Linux/Unix systems. For Windows, Mac and Ubuntu 12.04+ it is complete and should normally work out of the box. For other Linux/Unix systems there usually are a few prerequisites to be setup.

3.2.2 What can we do using Sikuli?

Sikuli Script can help the user to automate anything that is visible on the computer screen without use of any internal API's support. We can programmatically control a web page, a Windows/Linux/Mac OS desktop application, or even an iPhone or android application running in a simulator or via any VNC(Virtual Network Computing).

Sikuli cannot run on its own. It will require JRE(version 6 and above).So, in a nut-shell, running a Sikuli application will require:

1. Sikuli-X-1.0rc2-win32.exe or SikuliX-1.1.0-win32.exe
2. Java Runtime Environment (JRE) 6+ and/or above.

To run sikuli on numerous machines, load each machine with at most one instance of Sikuli application onto them.

Various Languages that are supported in sikuli are Python, Ruby, Scala, JS and Java on JVM.

3.2.3 Sikuli Architecture

Sikuli's Script is a library of Jython(Java + Python) and Java, that helps users in automating any GUI interactions using image patterns into keyboard/mouse events. The core of Sikuli Script is a Java library that consists of two parts: java.awt.Robot, who is responsible for various keyboard and mouse events to take place at desired locations, and a C++ engine , purely based on OpenCV, which is responsible for searching provided image patterns on the screen.

figure 3.3 shows Sikuli Architecture :[7]

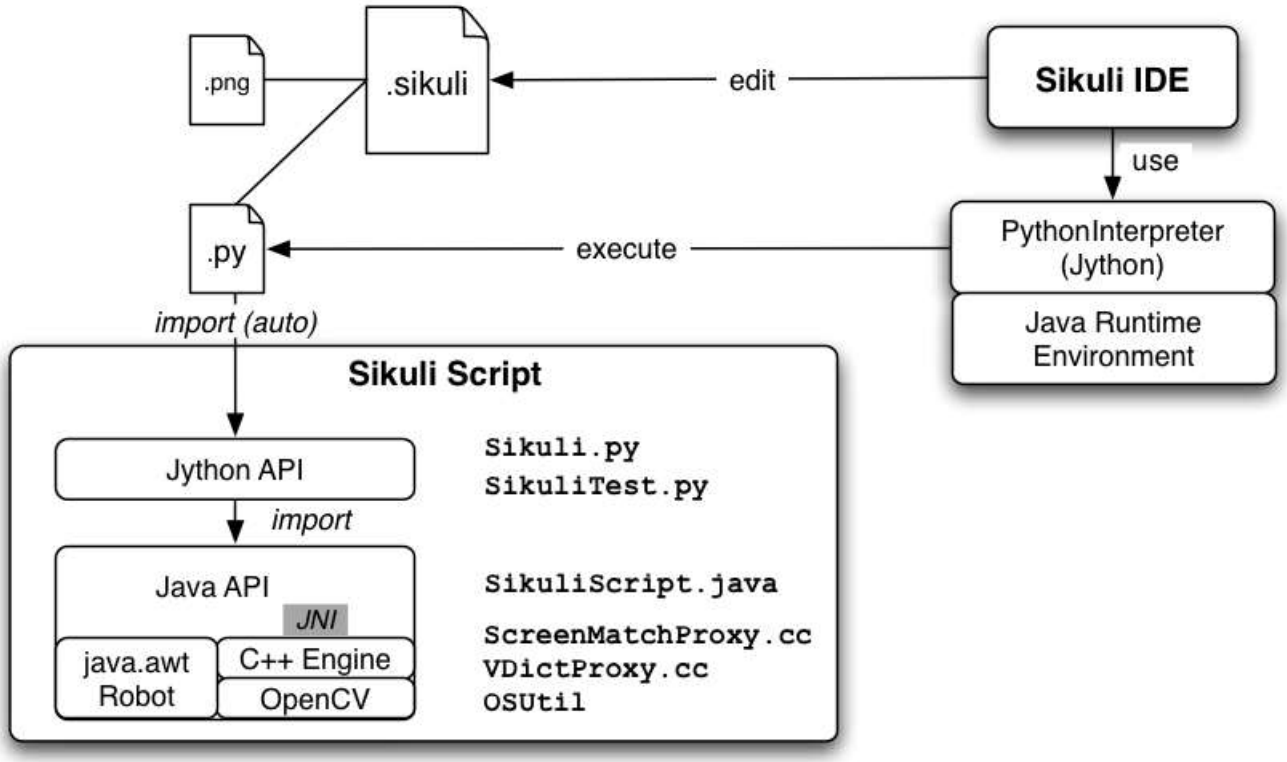

Figure 3.3: Sikuli Architecture

The C++ engine is linked to Java via a JNI or Java Native Interface, and is required to be compiled for each platform. On top of the Java library Layer is a thin Jython layer , provided to the end-users as a group of simple and clear commands. If a user wishes to use languages other than Python, it will be easy to add more layers for other languages running on JVM, e.g. Scala, Ruby, JS etc.

Various files extension that are generated when you create a sikuli script are

- **.sikuli**: It is the extension of the main script. It can be directly opened into Sikuli

IDE.

- **.skl**: It is the extension of an executable sikuli script.On double-clicking it, user can directly run the script.It encapsulates script to give an executable form of it, which can be loaded on each machine rather than installing IDE and loading scripts into it and then running. This is beneficial if we aim on hiding sikuli script so that no change can be made into the script.

3.3 My role in Arris

I have worked upon automating the process of Campaign creation. Automation process consisted of 2 parts

- Automating the Add Code object process
- Automating the Campaign Creation process

3.3.1 Automating the Add Code object process

In this section main aim was to automate the mundane process of adding Code objects. These code objects are categorized into 2 parts,**Platform code objects** and **Application Code objects**. As described above platform is for hardware and application can be used for Applications in set top box. Master or the Server is the STB which will provide services to the Slave STB or Clients. CLients have certain Applications which are necessary, but Master STB has all the Necessary and sufficient applications. To automate the process for both Master and Slave STBs , Sikuli Tool was used, with coding in Python. Basic steps include:

- Downloading the XML for the CAST
- Adding The code object using CAST GUI
- Code objects are always of type "GATEWAY"
- After adding Code objects, Campaigns can be created.
- For this process , Platform Code objects and Application are used. The platform objects are different for different type of STBs(Client or server).Application objects are common for all boxes.

- Naming the campaign.
- Selecting the Target model, or the type of set top box Model.
- Selecting the platform object. In this process, XML parsing is done and a list of available platform object is displayed in the GUI in the form of a list. From that list using python, position of desired platform object is computed. Once the object is found, it is selected.
- After this process , last step is to select all the desired and necessary Application objects required by the box. The Master STB can require upto iiIps and Slave can have upto 5 STBs.
- List of iips are also displayed into the GUI. This is also displayed after retrieving the list from XML after parsing it.From that list using python, position of desired Application code object is computed. Once the object is found, it is selected.
- This Process will create a campaign with selected IIPs and BIN. Based on the number of bin files number of campaigns are determined.

Chapter 4

Escape Defect Analysis

Escape defect analysis, also known as EDA is a process of detecting whether or not an escape has occurred , after testing of the product to be released was done. If an escape is found, it's root cause analysis(RCA) takes place, which is done by development or the testing team to determine the actual reason of its occurrence and after analysis, the problem is assigned to the respective individual(also known as assignees) or team of individuals for elucidation process.After the issue is resolved, its plan of actions are retrospected so that same action can be used to solve an issue of similar kind in future. In the nutshell, Escape Defect Analysis involves finding the effectiveness of phase detection. Development and Test team would identify why the specific issue was introduced and identify the action items to prevent it in future.

4.1 Process definition: EDA and RCA

RCA and EDA may be two different processes but they aren't mutually exclusive.

- **Escape Defect Analysis (EDA)** - An escape is a defect that was not found by, or one that escaped from, the test team. Implementing the escape analysis method for test improvement can increase the quality of software by lessening the occurrence of software defects.

- **Root Cause Analysis (RCA)**- Root cause Analysis is an approach for identifying

the underlying causes of why an incident occurred. Once the root of the problem is identified, we can prevent the problem from re-occurring.It helps us to find the root causes of problems instead of symptoms. Once the root of the problem is identified, we can prevent the problem from re-occurring by identifying the corrective measures.

The RCA/EDA is a continuous process and the data feedback to system will improve the quality of future deliverables. RCA is limited to improving the software quality and reduction of escape defects. This process also depicts a plan of action which states the procedure which are to be followed by development team for the issues that are Fixed and in Ready state after EDA process . The RCA would cover all Blocker and Critical defects created by VTE and customers. EDA will cover all Blocker and Critical defects created by customers.

Various functionalities of EDA Tool include:

- Graphical depiction of the data to be analyzed so as to draw a relatively logical conclusion.
- Sending mails to the assignees as a reminder for pending actions for their respective reported JIRA issue.
- Escape vs No-Escape graphs for detecting escapes in a particular duration of time(usually considered on quarterly basis).
- Exporting the Data to excel so that it could be store or used to draw other reasonable and important conclusions.

4.2 Terminologies and Phases

Various terminologies required by this section includes:

1. **Escape**: An escape is a breakaway or unsuccessful detection of a defect during the testing process, which can later turn out to be a potential harm for the product. Various reasons can be cumulative testing in which the defect got passed, human errors etc.

2. EDA: Escape Defect Analysis
3. RCA: Root Cause Analysis
4. JIRA: Software development tool used for Agile project teams.
5. CRs: Issues who's RCA is to be carried out.
6. Field (Customer Lab, Partner Lab, Customer Impact, Field Trail)
7. DVT: Design Verification Test.
8. PT: Reference to both PTS and PTH.
9. PTS: Product Test Software.
10. PTH: Product Test Hardware.
11. SIT: System Integration Test.

Various phases required by this section includes:

1. The Phases defined under these teams for defect classification are

   - Test Development
   - Test Environment
   - Test Execution
   - Test Planning

   The Major Categories defined under the Above Phases are

   - No Test Coverage
   - Unique Customer Environment
   - Incomplete Execution
   - Inadequate Planning
   - No Escapes

2. Table 4.1 shows the Defect Categorization.

   The format to be followed is: **"Team: Phase: Main category: Sub Category"**
   For Example:

SrNo	Phase	Main Category	Sub Category
1	Test Development	No Test Coverage	Extended Functionality Inadequate coverage Feature Interaction Stress/Endurance Tests Negative Tests Optimization impact Incorrect test case
2	Test Environment	Unique Customer	Environment Live Feed TV Streams Third Party Tools Box/Hardware Unavailable Hard to Replicate Customer Specific Configurations
3	Test Execution	Incomplete Execution	Incorrect test execution Test Tool Blocked due to test App Blocked due to Infrastructure Blocked due to lack of time Due to Indeterminate cases
4	Test Planning	Planning Related	Feature not Planned Build Not Tested Box not tested Code combinations /Cycle not planned Test by Analysis Parallel Testing
5		No Escapes	Not Reproducible Reset, Not Reproducible Not a Bug Out of Scope Duplicate Integration Build No Requirement Correct Lab

Table 4.1: Defect Categorization

- SIT: Test Development: No Test Coverage: Feature Interaction
- PTS: Test Development: No Test Coverage: Inadequate coverage

4.3 Escape Defect Analysis (EDA) Process Flow

When the CRs are available for analysis, the particular team analyzes and classifies the CRs using the Main Category and then the Sub Category to see why the CR was not caught by their team in the test cycle. In case the CR falls in 2 categories, i.e.: No Test Coverage and Test Planning, the priority is given to No Test Coverage category for adding the test cases in the test suites after which in the Planning phase the addition of test cases for testing is taken care of automatically (as found by following flow chart4.1)

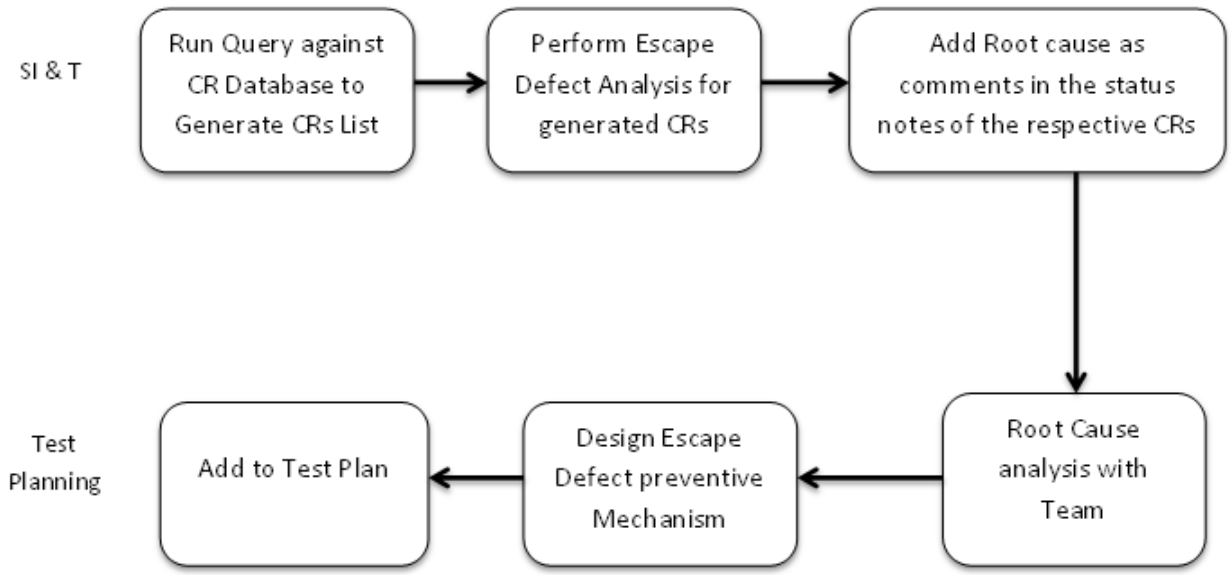

Figure 4.1: EDA Flow Chart

Teams are to use the following Analysis Chart to determine the EDA categories for the CRs. Any process that is to be carried out is to be done using the flow chart(Fig4.2 Fig4.3)

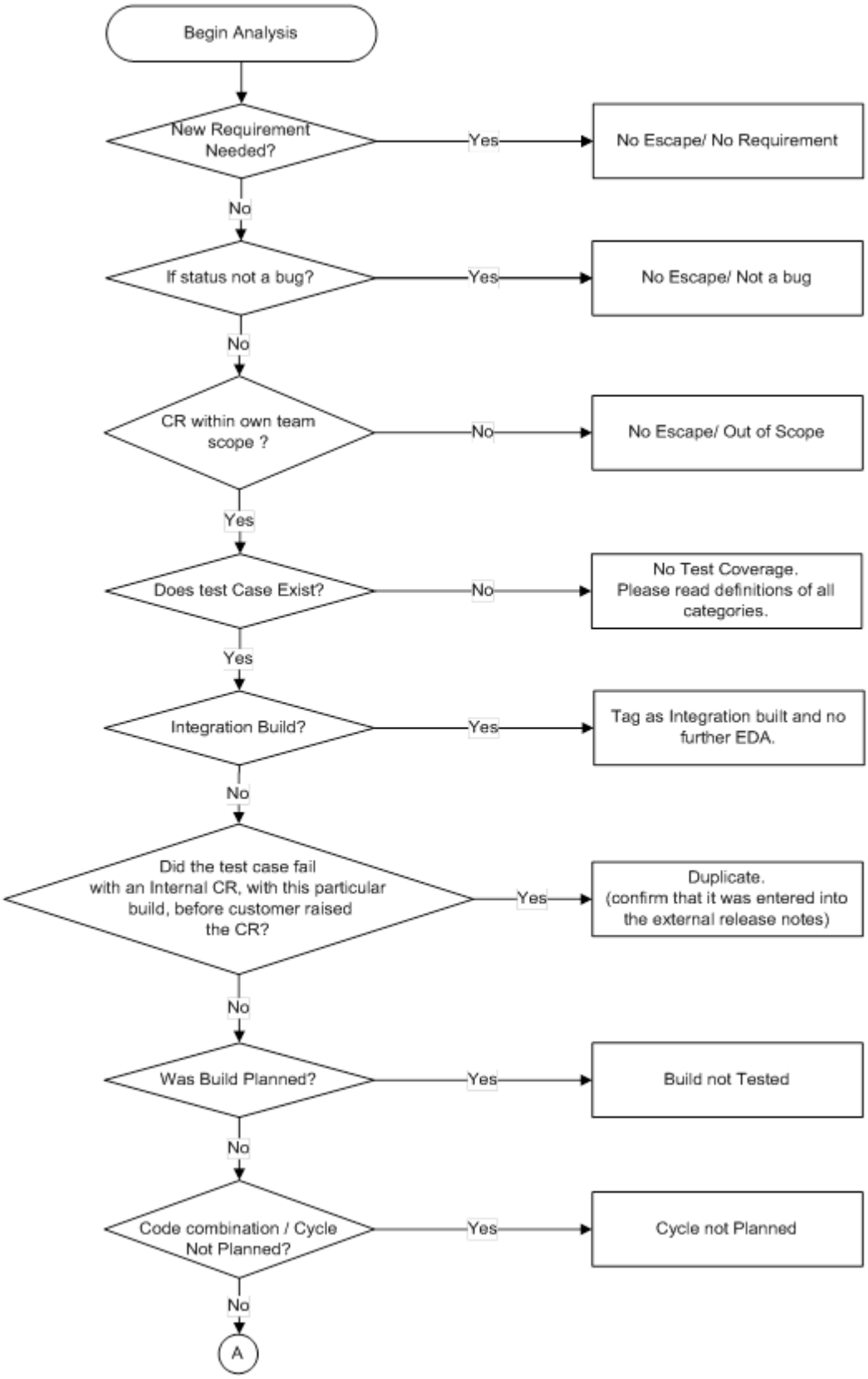

Figure 4.2: Team Flow Chart[1]

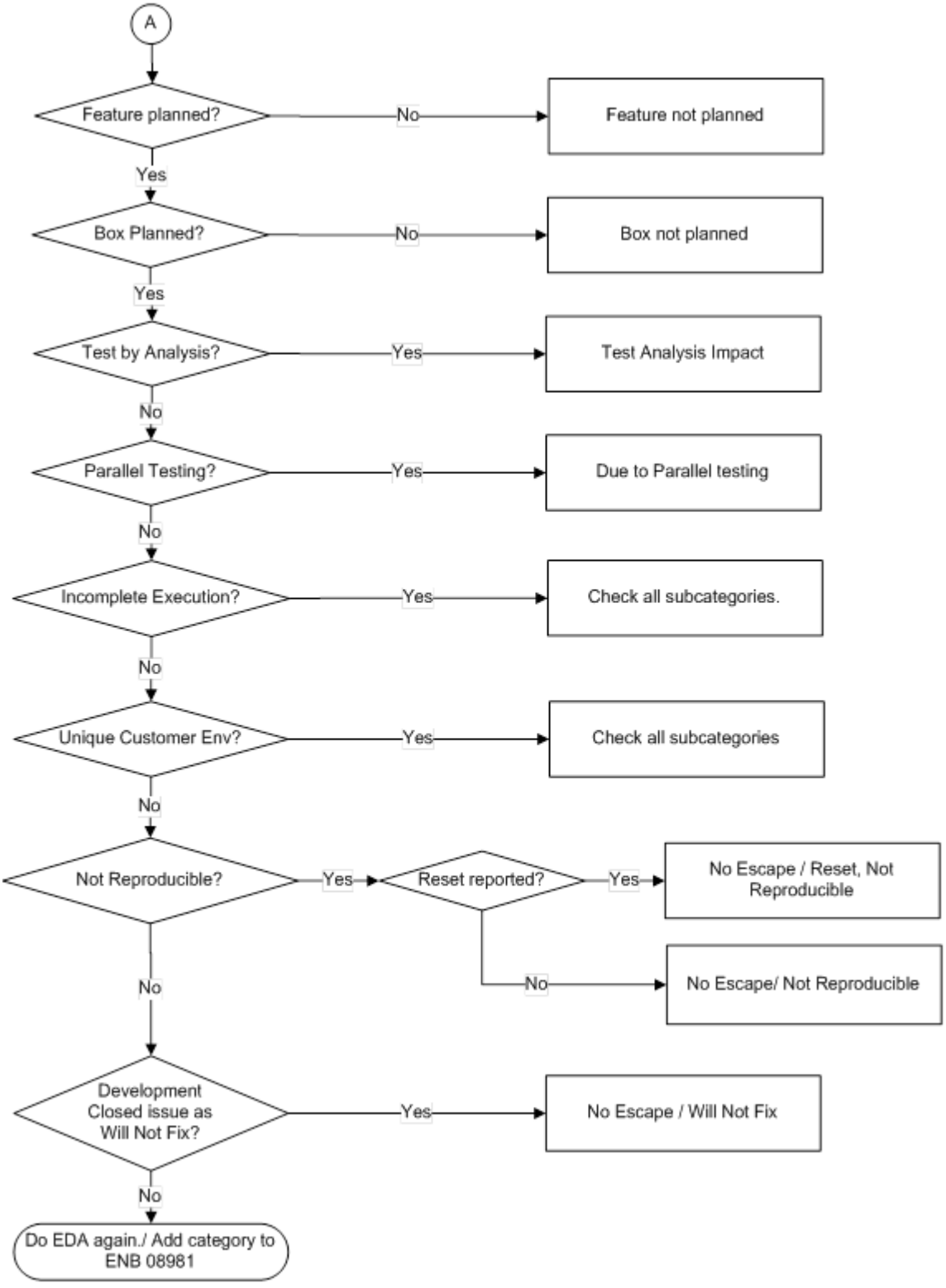

Figure 4.3: Team Flow Chart[2]

4.4 EDA Process Using EDA Database

4.4.1 EDA Database

EDA Database is a collection of information related to CRs that are collected from the JIRA and organized so that it could easily be accessed, managed, and updated with the current condition or CRs as a comment after RCA.

4.4.2 EDA Process flow using EDA Database

A report of open issues for evaluation is created and distributed to the EDA Team to provide an agenda for the evaluation meeting. Before each meeting team leads will coordinate entry of the Defect Classification Categories, root cause analysis, and actions required for open issues using the EDA entry page. The evaluation meeting will review the issues as a team to establish the responsible group and concurrence on any actions to be taken. This will involve determining if the issue is to be closed, deferred for further analysis, set as an Open Action for test development, or not to be analyzed. Management reports will be generated from the data entered using the JIRA reporting tools. The process is depicted in below image 4.4

4.5 Meeting Actions

The EDA coordinator conducts the meetings on a quaterly basis reviewing the external issues for a consensus on the reason for the escape and who covers the issue.During or after the meeting the EDA coordinator will update the EDA Overall status, Due Date, Analysis Completion date, and Primary Responsible group as appropriate

- **EDA Overall Status:** Depending on the analysis, the appropriate status is set. An issue is not closed until all groups have completed their analysis and actions.

Analysis	This status is set when it is determined that further analysis is required
Pending Action	This selection is made when the analysis concludes that corrective action is required to resolve the escape
Closed	When it has been determined that no further analysis or actions are required the status is set to closed.

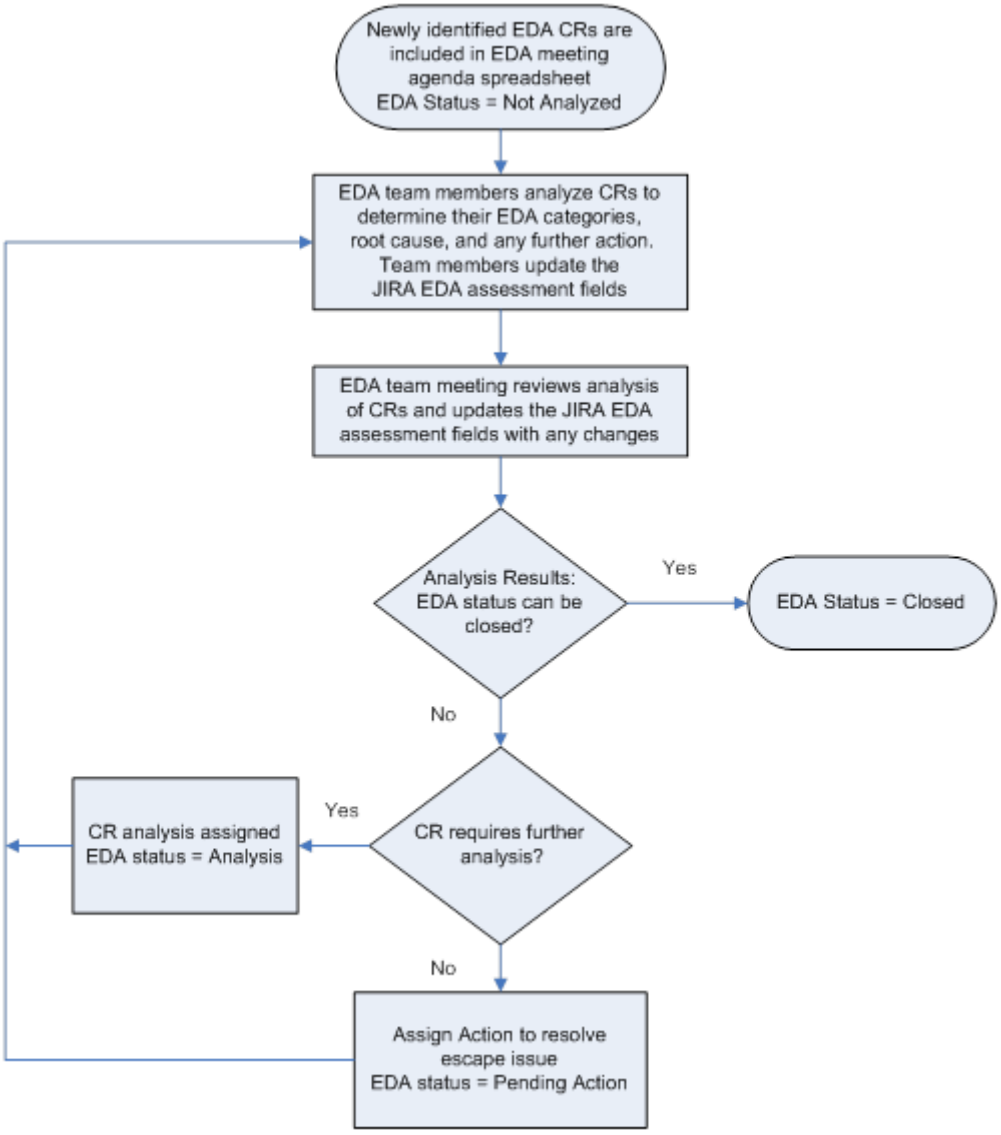

Figure 4.4: EDA Process flow using EDA Database

- **Due / Closed Date:** Since multiple groups may be working on an issue, the due date of the next action will be placed in this field. When all the actions are completed the overall status will be changed to Closed and the date of the closure will be entered.

- **Analysis Completion Date:** This is the date when all of the groups have completed their analysis of the Issue and the root cause has been determined. This would be the same as the closed date if no action items come out of the analysis. The Analysis Completion date is used to allow the data from an issue with action items to be included in reports before the issue can be closed.

- **Responsible Group:** For each issue one group will be designated as the one whose evaluation best represents the teams analysis.

4.6 Role in ARRIS : EDA Tool Enhancement

From project point of view, various enhancements in EDA Tool were done. They include:

1. **Capable to export generated graphs to spreadsheet or power point**: This task dealt with downloading of the graphs from the EDA tool and saving them into an image so that it is easy to use them for report generation and presentation purpose.

2. **The filter selection needs to be retained even after saving the data:** Filters provided in the EDA tool were required to be retained so that any other chaining action can be performed on the filtered data.

3. **Escape Report data needs to have the columns that the Admin can configure:** This task dealt with customization of the existing columns in the EDA Grid. Hide/Show functionality was added so that only selected columns can be viewed as and when required . This was added with the sole purpose of controlling column visibility . Other logical reasons can be

   (a) Necessary conclusions could be drawn.

   (b) Viewing only certain related columns.

   (c) Drawing other logical conclusions for EDA process.

4. **Additional graphs needs to be generated by the tool:** This task's agenda was to generate additional graphs based on which various conclusions can be drawn which are not physically visible at that point in time in the EDA Tool.

   - **A consolidated graphs involving all the projects:** a sub task to achieve the task described above.

5. **Grouping of Filter Name and Arrangement of Filter Name**: The EDA tool retrieves filter data by grouping various specified filter names . Unfortunately this grouping was not logical. For example, if we have `FILTER_NAME` = **cable** and `FILTER_NAME` =`LAN_cable`. The two filters are not mutually exclusive and so

can be grouped together as one, under a different name or same name as one of the `FILTER_NAME`. So, privileges were provided to the admin with the flexibility to consolidate and re-arrange them.

6. **Mailing option should be enabled in the tool for the following conditions : 1. When any CRs are added for analysis, 2. When a CR is pending and needs action from the user**. For this task, mailing functionality was added whenever a new issue was created and assigned to any of the assignees discussed above, or for the purpose of sending a reminder with a list of pending actions in their names. Figure 4.5 is a sample mail sent as a reminder.

Hi All,

Please look in to the "Pending CRs" for the projects which you are dealing with and request you to close the same at the earliest based on the Admin comments. Details of the CRs are as mentioned below.

Issue Key	Filter Name	EDA Overall Status	Due Date	Admin Comments	Responsible Groups
XXXX	XXXX	Pending Action	09/02/2013	XXXXYYYYZZZZ	DVT
XXXX	XXXX	Pending Action	08/05/2013	XXXXYYYYZZZZ	SI&T

Regards
Admin

Figure 4.5: Sample Mail Format

7. **Enhancement of EDA tool to suite for different projects which has specific Jira URLs:** In this task major concern will be in adding a new project with various functionalities so that its EDA and RCA can be done. Every functionality required for the project after requirement gathering and analysis, will be added into the EDA tool as an enhancement to it.

8. **DTA entropic entries to be added in separate table in database and populate the same along with other Jira issues**: Some conflicting entries of DTA project will be seperated along with their JIRA issues details.

A sample screen shot of EDA Tool is depicted in fig 4.6

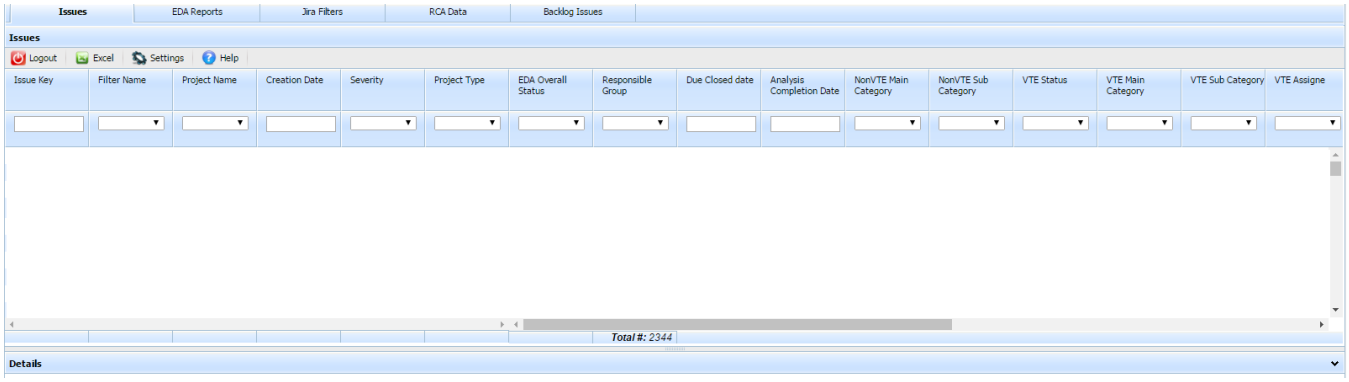

Figure 4.6: A bird's eye view of EDA Tool

Chapter 5

Firmware Up/Down grade process Automation for DOCSIS Modems

In 1992, CableLabs started exploring protocols for high-speed, duplex data communication with experimenting upon pre-existing cable plants along with television and voice tele-communcations. as a result of this they came upwith a standard popularly known as DOCSIS (Data Over Cable Service Interface Specification).So let us get some briefs about it and what all is carried out as a part DOCSIS

5.1 A Brief History- DOCSIS

- Introduced by CableLabs in 1992, has now become a standard for data over cable so as to achieve High speed network for data , voice and video.
- DOCSIS provided a even set of vendor-independent interface requirements to the subscriber modems also short-termed as CM and a head-end cable modem termination systems (CMTS) used in high-speed data over cable systems.[8]

5.1.1 DOCSIS in depth

There are mainly four versions of DOCSIS, which are 1.0, 1.1, 2.0 and 3.0.

- **DOCSIS 1.0 :** DOCSIS 1.0 provides basic broadband Internet connectivity for one or more devices in the home. Downstream data rates are 38 Mbps and are supported with a rate of 5 Mbps in the upstream direction.[8]

- **DOCSIS 1.1 :** With the introduction of DOCSIS 1.1, upstream rates were doubled , and support for Quality Of Service features was added .

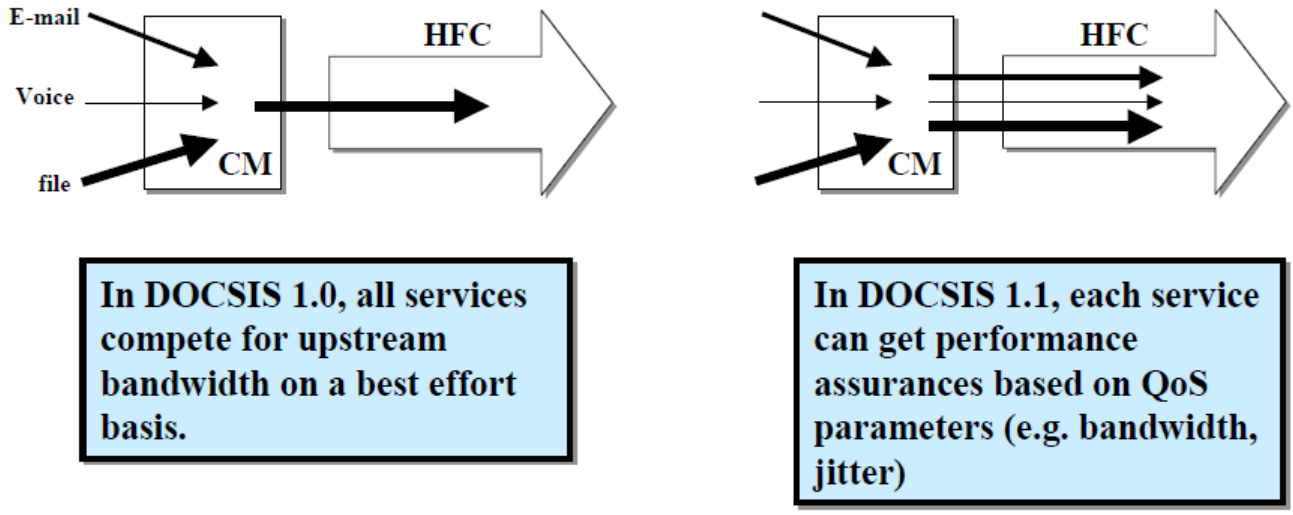

Figure 5.1: Docsis 1.0 and 1.1 version QOS Comparison

- **DOCSIS 2.0 :** DOCSIS 2.0 was introduced to achieve an increase in the Upstream and downstream rates [8]. Upstream rates were now supported up to 30.72 Mbps. Also, support was added the Baseline Privacy Interface (Baseline Privacy Interface Plus (BPI+)).

- **DOCSIS 3.0 :** DOCSIS 3.0 introduced the channel bonding capability concept . Channel bonding allows both upstream and downstream data flows to be combined onto multiple channels at once, thus increasing the effective throughput to 100 Mbps in both the upstream and downstream directions.[8]

- In addition, DOCSIS 3.0 provides support for IP Multicast, IPV6, enhanced security , and improved physical-layer, MAC-layer and Network management support.

- Any version of DOCSIS is fully backward compatible with the previous DOCSIS versions, like DOCSIS 3.0 is backward compatible with DOCSIS 1.0, 1.1, or 2.0

5.1.2 Block Diagram : DOCSIS Cable Modem System

Prominent facility of the DOCSIS Cable Modem System is to send Internet Protocol (IP) Packets transparently between the Headend station and the Subscriber Location. To carry out this process, the system has various components as named below:

- **Cable Modem Termination System (CMTS)** located at the headed. This is responsible for getting the stream of data and send it to the end users or devices
- **The Cable Network**. This acts as a media for passing the stream of data to and from the CMTS and CMs
- **Cable Modem (CM)** located at the Customer end. These are the end devices which will then further distribute the data stream to other connected and compatible devices.

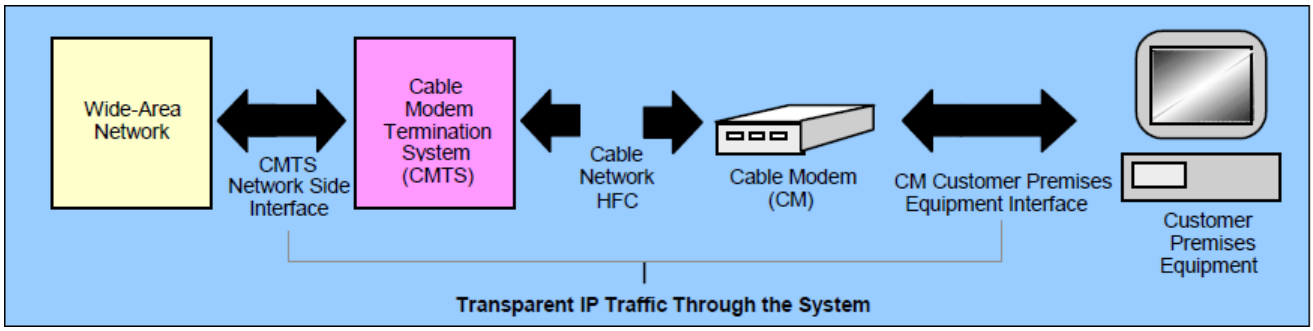

Figure 5.2: Docsis Cable Modem Architecture [1]

- The **CMTS** will communicate to the **"Outside World"** via a WAN.This "Outside World" comprises of various Docsis support devices like **Network Manager**,**TFTP servers**,**Time-of-Day servers** ,**DHCP servers**, etc.
- The CMTS and Cable Modems are connected to each other via Cable Network which facilitates data stream transfer between them. Usually it is a RF cable.
- CM in turn provides Facilities to End devices or Equipments.

There are various protocols used for various functions of the Docsis modems. These various functions include:

- Getting IP from the DHCP server. This uses DHCP Protocol.
- Ranging and Synchronization .
- Firmware Up/Down grade.This uses SNMP,TFTP HTTP Protocol.

5.2 DOCSIS DHCP Server

The DHCP server assigns IP addresses to client computers. These addresses are leased to clients (Cable Modems or CPEs) for a certain period of time.After that it expires and can be used to assign to other CPE devices. These IP addresses can be reserved or assigned from the IP pools. Once the Clients get registered to the DHCP server, they can be authenticated based on their MAC address. The process is as below :

- CM sends a broadcast DHCP request via the CMTS to the DHCP Server
- DHCP server will send back the following:
  - IP address
  - Subnet Mask
  - CM config filename and IP address of TFTP server
  - UTC offset to establish local time
  - Time Of Day Server's IP address

5.3 Ranging of Docsis Modems

Ranging is the process of synchronizing with the CMTS in every aspect. Various steps include

- Registration
- Downstream Channel Search
- Monitoring For SYNC
- Upstream Channel Search and Obtain Upstream Parameters
- Initial Ranging
- Auto Adjustments
- Admission Control

5.3.1 Registration

This process is the first step in Ranging. This happens when the Modem is connected to the CMTS for the first time. Various steps in this step include:

- CM generates a Registration Request (REG-REQ) as shown in fig 5.3.
- contains config parameters obtained from TFTP config file:
  - Down stream frequency, Up stream channel ID
  - Network access config settings
  - Class of Service
  - Modem Potential

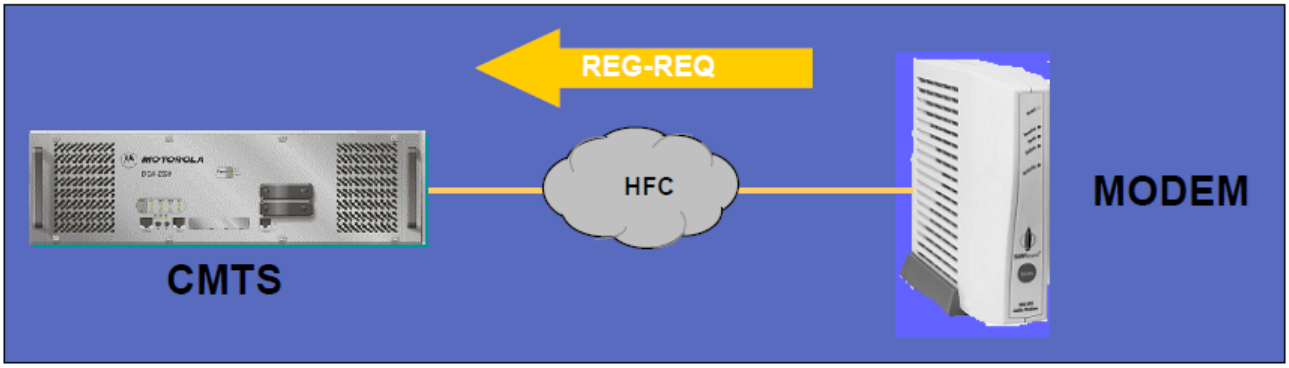

Figure 5.3: Docsis Cable Modem Registration Process [1]

5.3.2 Downstream Channel Search

- CM looks up for a down stream channel
- Synchronize with **64-QAM or 256-QAM**
- Synchronize with **FEC**(Forward Error Correction (FEC) encoding) and **MPEG**(188 Bytes, 4 Byte header)

5.3.3 Monitoring For SYNC

- Timely transmission by CMTS
- SYNC messages containing a time-stamp that correctly identifies when the CMTS has send the message

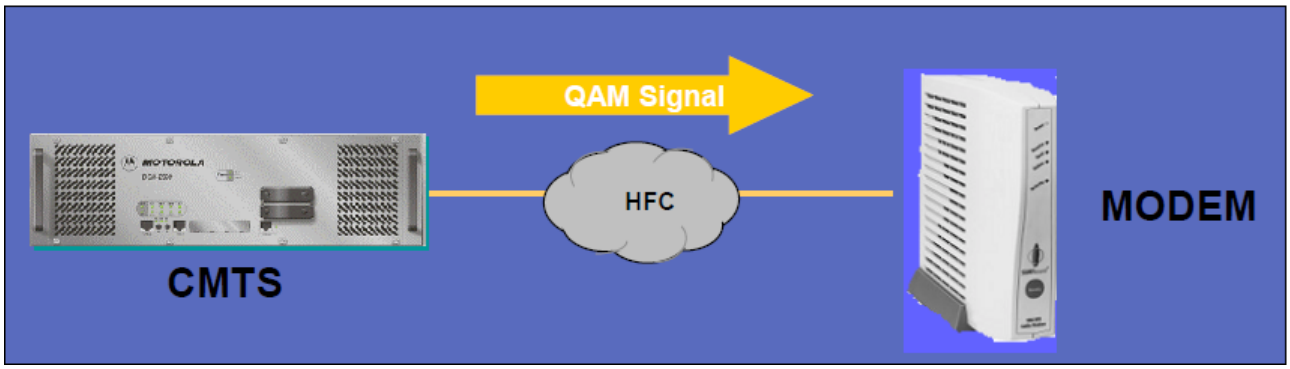

Figure 5.4: Docsis Cable Modem Downstream Channel Search Process [1]

- CM synchronizes its time-based reference clock so as to transmission on the up stream will fall into the correct mini-slots sync messages.

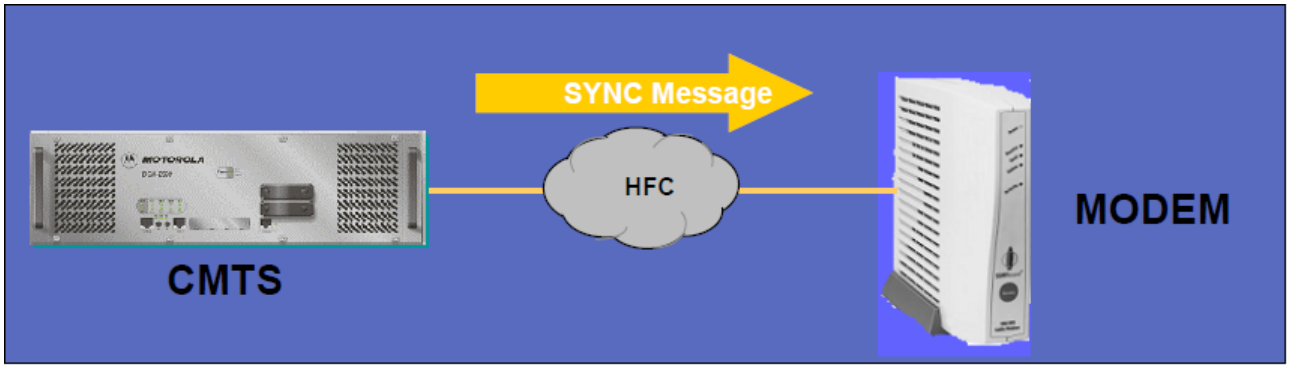

Figure 5.5: Docsis Cable Modem monitoring for SYNC messages [1]

5.3.4 Upstream Channel Search and Obtain Upstream Parameters

- Monitor for **UCD or Up stream Channel Descriptor** message
- These are also timely transmitted by CMTS
- UCD describes attributes of the up stream channel such as:
  - mini-slot size
  - upstream channel ID
  - downstream channel ID
  - burst labels

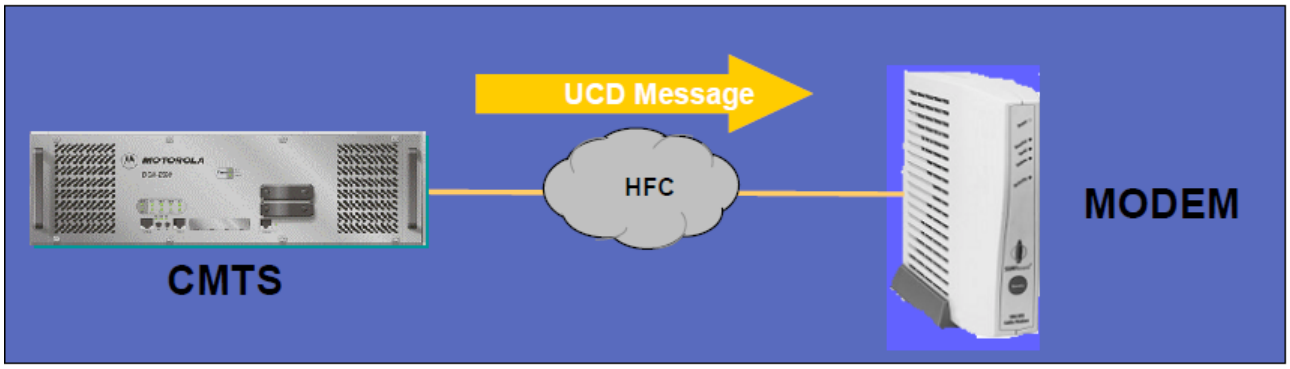

Figure 5.6: Docsis Cable Modem Upstream Channel Search Process [1]

5.3.5 Initial Ranging

- CMTS timely transmits **MAP**(Media Access Protocol) messages.
- Upstream channel Allocation Map (MAP) includes:
  - Initial subsistence Interval (broadcast interval) with start and end of connection contingency.
  - CM replies with a Ranging Request (RNG-REQ)

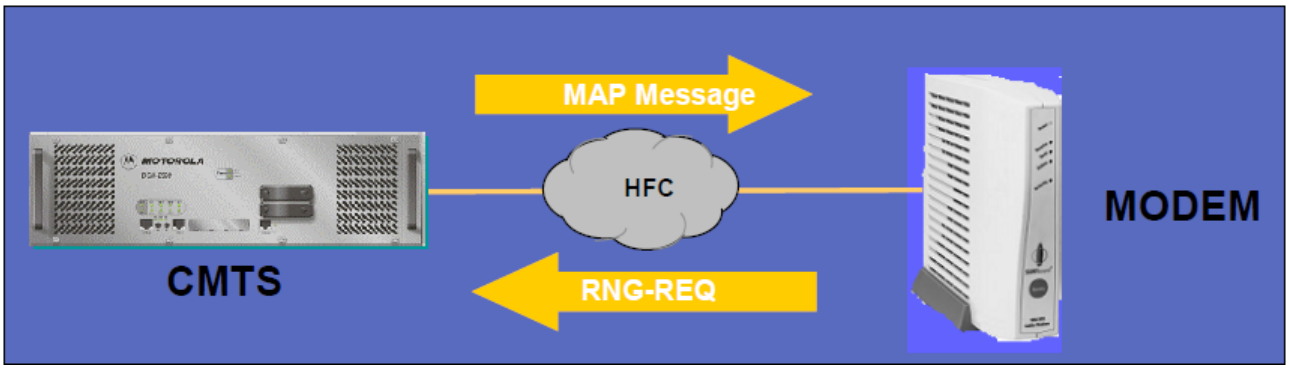

Figure 5.7: Docsis Cable Modem Initial Ranging Process [1]

5.3.6 Auto Adjustments

- CMTS receives first Ranging Request from CM
- CMTS responds with Ranging Response (a unicast message)
  - appoint a SID and allocates bandwidth to this SID.
  - accustom power levels, timing offset, and frequency adjustment.

– Sets downstream and upstream channels.

- CMTS starts Admission Control

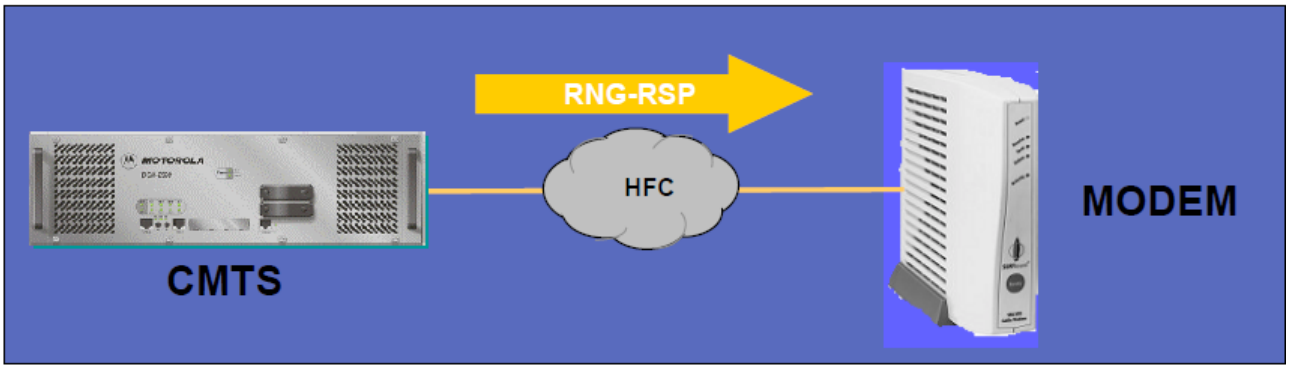

Figure 5.8: Docsis Cable Modem Auto Adjustment Process [1]

5.3.7 Admission Control

- CMTS allocates a Temp SID for the CM and puts the CM in the Forwarding Tables
- CMTS sends MAP packets with Station Maintenance opportunity for that SID
- CM ranges with the latest settings
- CMTS sends RNG-RSP to indicate success or failure of Admission

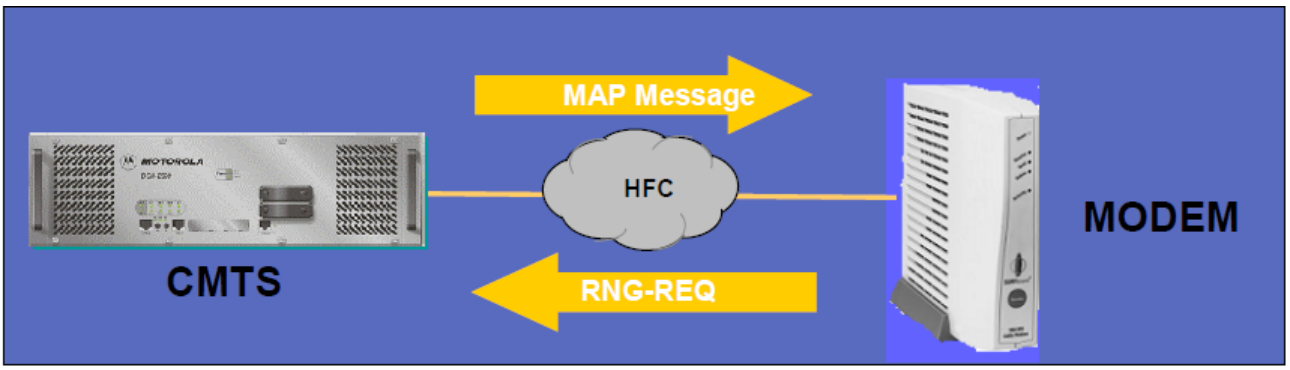

Figure 5.9: Docsis Cable Modem Admission Control Process [1]

5.4 Docsis TFTP Server

The TFTP or Trivial File Transfer Protocol is used for uploading or downloading files from Remote locations. The Configuration file is a file that can be used by modems to indicate various parameters like file's name, location to copy, speed thresholds etc.The following settings MUST be included in the configuration file:

- Network Access Configuration Setting
- Class of Service Configuration Setting

Other parameters like below are optional

- Downstream Frequency
- Upstream Channel ID
- Software Upgrade filename
- SNMP Write-Access Control
- SNMP MIB Object
- Software Server IP Address. etc.

Note: The TFTP Server runs on port 69 and uses UDP protocol.

5.4.1 Transfer Operational Parameters

After DHCP operation, CM must download the configuration file from the TFTP server. The Server address is specified in the siaddr field of the DHCP response.

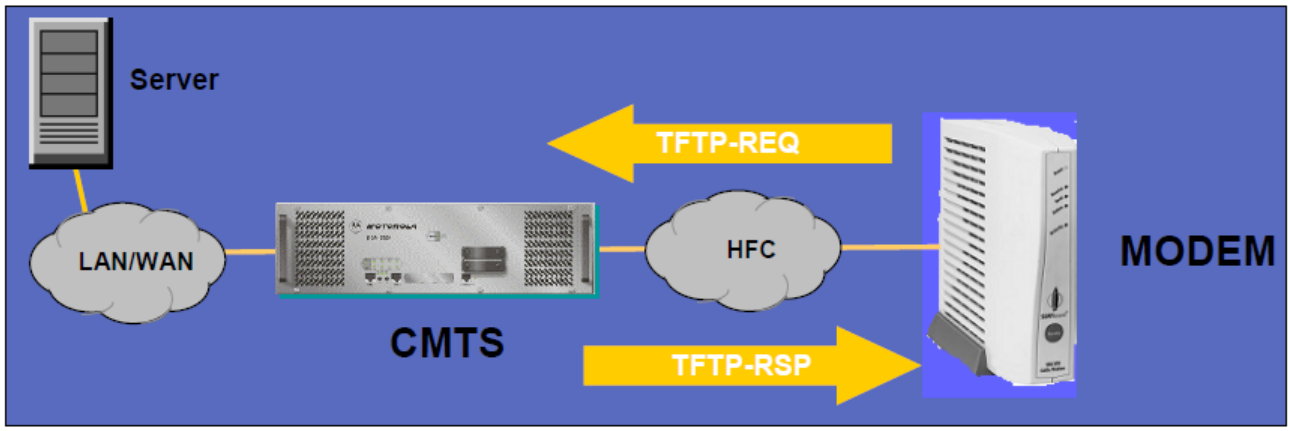

Figure 5.10: Docsis Cable Modem Transfer Operational Parameters [1]

5.5 Baseline Privacy

Baseline privacy standards were adapted for DOCSIS for providing user data privacy by encrypting traffic flows,upstream and downstream. This standard also provides cable operators basic protection from theft of service. Baseline Privacy supports Mechanisms for:

- Authentication: CM to CMTS and CMTS to CM
- key distribution: traffic keys and lifetimes
- 56 bit DES Encryption

5.5.1 BPI+ Enhances BPI Capability

There was a stronger BPI introduced with the introduction of DOCSIS 2.0, with the following motives

- Stronger crypto mechanisms
- Support of future upgrade of crypto capabilities
- Strong authentication
- Dynamic security associations

5.6 Firmware Up/Down grade

To understand how the firmware is downloaded onto the Modem, a basic level understanding of SNMP, TFTP and MIBs is required.

5.6.1 SNMP

SNMP is a network management protocol, which has 3 basic entites,

- Device to be managed
- SNMP Agent, and
- Management Unit / System

These devices can be routers, hubs , switches etc which reside on Managed network and have agents installed in them Agents are nothing but softwares that help device to understand SNMP Language. Various piece of information about the managed device will be accessed by SNMP using MIBs.MIBs are properties or functionalities of the monitored device Systems that run NMSs will help in monitoring devices.The detailed list of entities of SNMP are as below:

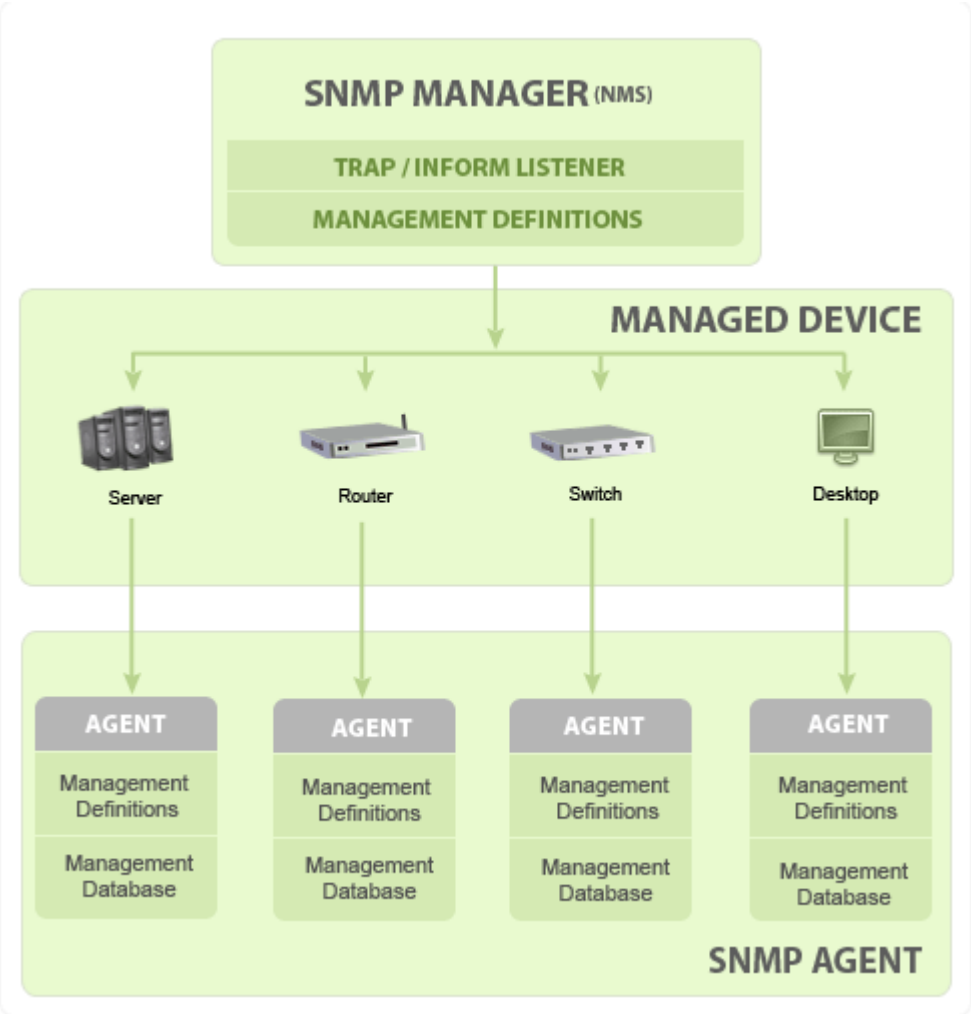

Figure 5.11: Basic View of SNMP [2]

- SNMP :SNMP is an Application layer protocol which is used to manage networks and uses TCP/IP.
- SNMP Agent: It can be any end device like CMTS , pcs etc that can understand the "SNMP dialects"
- MIB or Management Information Base :is a virtual Database of information that is required by SMI.
- Structure of Management(SMI) :SMI provides an standard for any organization who want to create their own MIBs.
- Network Management Station :It is an end device/ manager that will gather SNMP agents for Information[3]

5.6.2 MIBs

MIB is a structural view of a virtually existing database of network entities being managed.Each entry in this database is or can be identified by unique id called **Object Identity or OID**.—GetFromPPT[2]. The OIDs specify a particular Function or Property of the entity. For Ex, consider a router. It can have properties like MAC address, IP Address, etc. Each object composes of one or more variables referred as object instances **Iso(1).org(3).dod(6).internet(1).mgmt(2).mib-2(1).system(1).sysDescr(1).0** which equals **1.3.6.1.2.1.1.1.0**. Also, Managed objects can be classified into two types (a). Scalar Objects (b). Tabular Objects

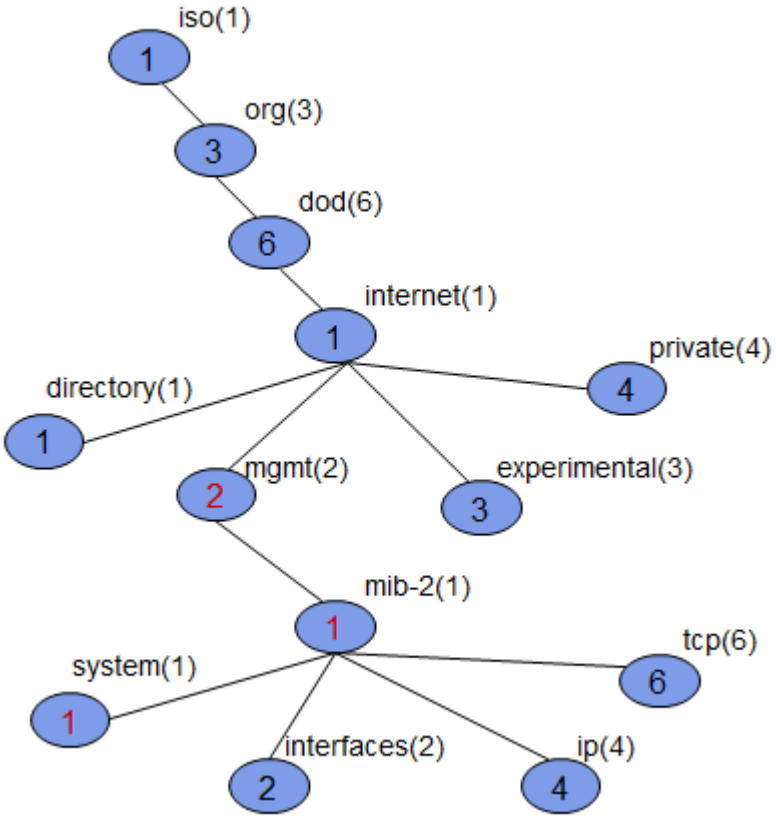

Figure 5.12: MIB Tree[3]

5.7 My role In Arris

:

My role in has been dedicated to the understanding the basic steps involved in firmware up/down grade and automating the same to avoid unnecessary delays . Knowledge of various protocols like SNMP,DHCP, TFTP and HTTP was required before au-

tomating the process. A basic knowledge of other terms like MIBs, OIDs, the Modem, CMTS Headend functioning, Ipv4, Ipv6, Configuration File etc. The Scripting language used is python with many packages required to support the automation process.

5.7.1 Scripting Language and Required Package

The Scripting initially was chosen to be batch scripting. But due to limitations of batch scripting, Python was selected as it overcame the issues with batch scripting and also due to its robust nature and ease of available related packages required for the automation process. Various packages required for the process were

- PySNMP PACKAGE: It is a package used to communicate with the device and retrieve or set values like "Current Upstream Rate","Current Downstream Rate", "Currently installed File name" , "TFTP address", "Configuration File name" etc using MIBs and SNMP v1/v2c/v3 engine. It is Library written in pure-Python. Supports editable MIBs, asynchronous operation(SNMPGET, SET) and multiple transport(SNMPWALK, SNMPBulkWalk).Version used while development : pysnmp 4.3.3.

- XlsxWriter PACKAGE: It is a python package to create and alter an Excel sheet. Various fuctionalities include write using indexes and Alphabetic notation of the cells. Calculations using excel formulae is also supported. Read functionality is not supported by this package

- Openpyxl PACKAGE:It is also a python package to create and alter an Excel sheet. The functionalities are same as XlsxWriter but in addition to them, it can read the existing excel sheet.

- win_inet_pton PACKAGE: It is an extension to a pre-existing package "socket" in python. It allows usage of Ipv6 addresses in the script.

5.7.2 Script Functionalities

Various SNMP request / response type required for the script include :

- SNMPWalk or GetNextRequest: A request to "Walk" through the MIB Tree

- SNMPGET or GetRequest: A request to GET a value from the MIB Tree

- SNMPSET or SetRequest: A request to SET a value already present in MIB tree
- GetResponse: A response to GET, SET, WALK or TRAP queries. Sort of an acknowledgement of queries

These SNMP contribute to the script in a major way.The Script supports both IPv4 and IPv6 and thus necessary MIBs. Some functionalities of the script are as follows

- Getting the MAC address, TFTP IP address, Firmware Filename(s) etc from the user and based on MAC address getting the current IP of the Modem from CMTS using Telnet.
- SNMPGet request to check the current state of the Modem, i.e is it up, or in ranging state.
- SNMPSET to set the required values to up / down grade the firmware of the modem.
- a SNMPWalk on only certain MIB values to get error values if any.
- Constantly setting and getting SNMP MIB values to ensure the errors that arise are reported to the user and thus are taken care of so that the script never goes into an inconsistent state.
- The SNMP SET and GET are facilitated by PySNMP package.
- Various basic and advanced level error handling is done by the script. It includes checking of correct version of IP address that is obtained from CMTS is supported by the script, checking void or nullability of the necessary input parameters , checking and handling various execution errors etc.

5.7.3 Firmware Up/Down grade : The process

- The process begins with creating an input file with various necessary parameters like **TFTP server IP**, **MAC Address of the box**,**CMTS IP**, **Number of images**, **List of firmware Images**, **location of the images stored** etc
- A small manual check is to be done on TFTP and HTTP server so as to determine that they are up and running before running the script.

- The script can be ran now. The user will be requested to specify the Modem's Model name. This is required in the script afterwards.
- Next, the user will be requested to check their input file before proceeding and if user chooses to proceed, they will be presented with the values they have specified.
- After this, The IP of the modem can be found using telnet operations facilitated by the telnet lib of python.

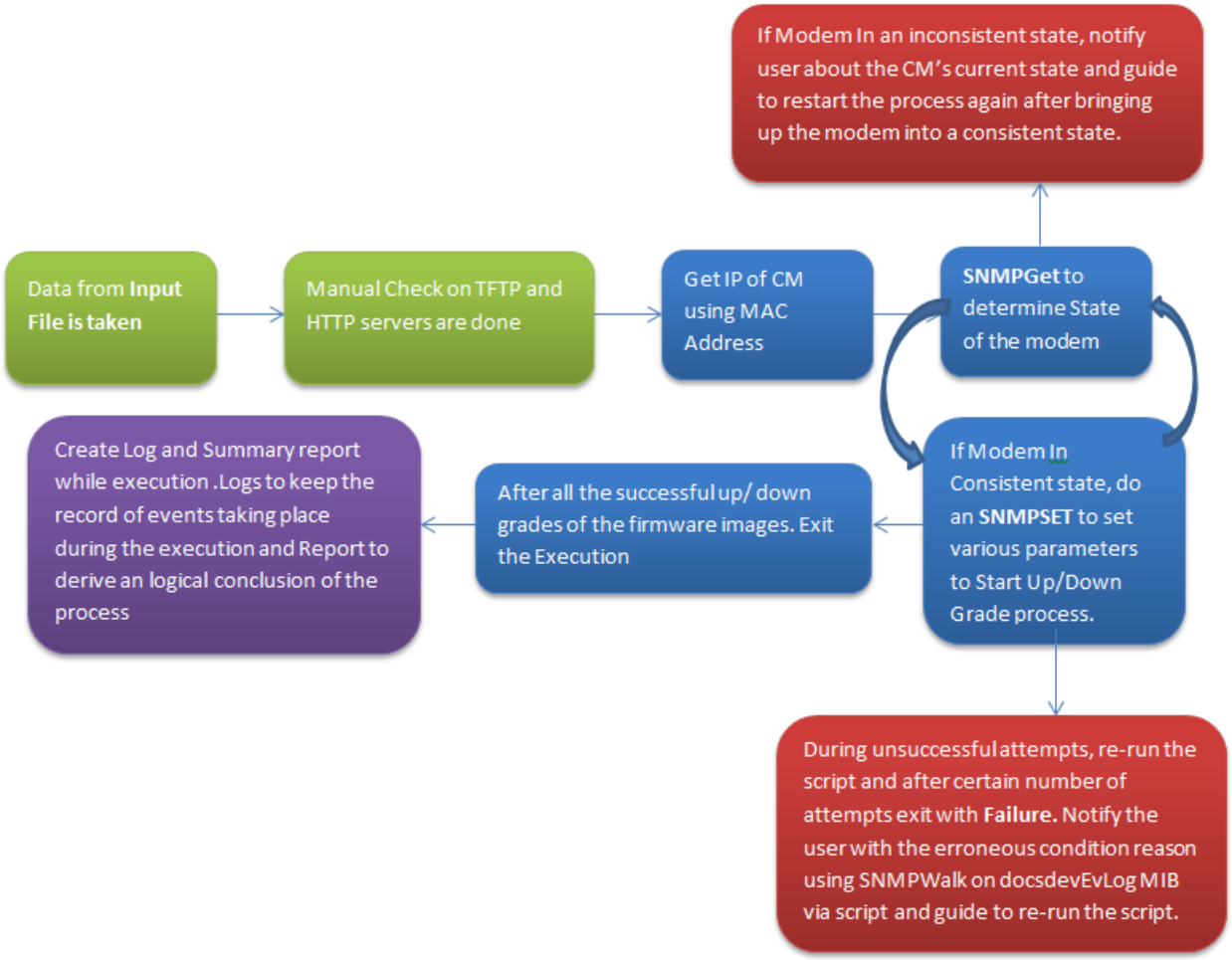

Figure 5.13: Process Flow of Firmware Up/Down grade

- After this the user will be presented with a menu to make a selection of Protocol to be used for the process. It can be either of them at once : TFTP,HTTP or Both Together.
- Once the IP is obtained and the choice of protocol is made, one can proceed with the up/down grade process. But before proceeding, the consistency and the current

state of the Modem or CM is to be checked. To do so, a SNMPGET is required to be performed on certain MIBs. They will return with the current status, current image name and other info to determine the consistency of the CM.

- After the necessary checks on Inputs and state of the CM is made, an SNMPSET is performed using PySNMP Lib. The values needed to be set are **Protocol used(TFTP/HTTP)**,**Firmware Image name**,**Reset of log MIB**(To be done so that the MIB values areconsistent and easy to operate upon)and lastly a set value to **Admin Status** MIB to start the code download process.

- After the SNMPSET , a random wait based upon the model of the modem is added so that before the modem comes up with the specified image, the script will constantly check the for the MIB **"CurrentOperStatus.0"** to determine the status of the process.

- In case of failure of up/down grade of previous image, the user is notified about the failure with it's reason using a SNMPWalk on **docsdevEvLog.x** MIB and the process is restarted again. If the process constantly fails for x number of times, the process will be aborted and the user will be notified with the reason and will be guided to run the script again.

- In case of success, the modem is brought back to the base image(an image that was initially loaded onto the CM) and the process is repeated with the second, third,... nth firmware image .

- while the process is running, logs are generated side by side with the execution.

- After successful completion of the script with all the images, a Summary Report is created listing the up/down gradation from Base image to Image x and then back to Base Image with the initial and final times and the time taken in total, with the protocol specified to run the same.

- The process is as depicted in the image 5.13

Chapter 6

Future work

My future work will concentrate upon EDA tool enhancement and some part of DOCSIS firmware Up/down Grade using Config Files and later I may be assigned tasks for AutoMOTO tool development. Some highlights of future work include:

- **Enhancing the tool to fetch required Jira field details:** improving query so that fetched data from the Jira can be improved.
- **Escape CRs for no test coverage must have the Status of the CR (Example Closed, Open, In progress etc).**
- Code Optimization of EDA tool.
- **Firmware Up/ downgrade of using Config File:**. A configuration file is a file loaded with MIB OIDs and their respective values to be assigned. Instead of doing a teadious process of SNMP GET,SET,Walk, a config file can be used to do the same in shorter amount of time.
- The users of DOCSIS modems can use Docsis app to do their CM's Firmware Up-Down Grade.

Chapter 7

Conclusion

It has been a learning experience while working as an intern in Arris India. Exposure to various technologies used in Arris helped me enhancing my knowledge. Experience of various field Ranging from learning python, to understanding and using Sikuli,to enhancing the EDA tool helped me understanding many concepts in a much better way and also gave me a practical exposure.

STBs helps in display the transmitted content onto the TV. Each STB requires special bin and iips files to function properly and desirably. This process can be carried out using the process Campaign Creation.

Escape defect analysis, also known as EDA is a process of detecting whether or not an escape has occurred , after testing of the product to be released was done. If an escape is found, it's root cause analysis(RCA) takes place, which is done by development or the testing team to determine the actual reason of its occurrence and after analysis, the problem is assigned to the respective individual(also known as assignees) or team of individuals for elucidation process.After the issue is resolved, its plan of actions are retrospected so that same action can be used to solve an issue of similar kind in future. In the nutshell, Escape Defect Analysis involves finding the effectiveness of phase detection. Development and Test team would identify why the specific issue was introduced and identify the action items to prevent it in future.

Docsis Modems follow the standards and specifications provided by the DOCSIS Stan-

dards by CableLabs. They have various steps from acquiring Dynamic IP from DHCP server , to ranging, to latching to being operational and in Sync with the Time-of-day Server at the Cable modem Terminal System end. Firmware up /down grade process requires SNMP protocol to determine the current state of the CM and to set the required values so as to facilitate the up /down grade process. TFTP and / or HTTP are the protocols used for File/Image/Firmware Image transfer from the remote location to the CM via CMTS.Python as a scripting language provided a strong base to facilitate the process, along with various libraries like PySNMP(SNMP for Python),Xlsxwriter and openpyxl (XLSX libs for python).

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