CRM & MOBILE TECHNOLOGY

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in
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CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, **"CRM & MOBILE TECHNOLOGY"**, in partial fulfillment of the requirements for the award of degree of Master of Engineering in Computer Science And Engineering submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of Mr. Amit Bhushan Jha, (Project Manager, ST Microelectronics), Dr (Mrs.) RaviKiran (Associate Professor) and Dr(Mrs.) Seema Bawa (Professor and Head, CSED) refers other researcher's works which are duly listed in the reference section.

The matter presented in this thesis has not been submitted for the award of any other degree of this or any other university.

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This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.

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Karan Salhotra

ABSTRACT

"To satisfy the customer is the mission and purpose of every business."
Drucker (1973)

Customer Relationship Management (CRM) discusses the management of relationships with customers through various technologies. It has evolved over the years to play a very important role to aid organizations retain their customers. To retain customers, organizations must understand why customers leave initially and realize a solution which would stop the customer leaving. Organizations must then question themselves as to why they need to retain customers, and how they will benefit from retaining their customers. Customer retention strategies are designed to help aid organizations, it is shown through the customer retention model that no one strategy is superior. It is better to create an overall strategy and implement it. A framework is then created to assist the implementation with a list of guidelines which should all agree with the strategy before its implementation. A customer retention cycle is designed to help understand the process from initial implementation of the CRM technology right through to retaining customers. The cycle shows loop facilities to allow the organization to return to previous step if they are not successful at any stage.

Customer relationship management (CRM) was the buzz word of the 1990's. Many researchers such as Peppers and Rogers, (1999) have tried to describe it. In some businesses, CRM is seen as extended databases full of information about the customer to help extend sales while others see it as being a tool specifically designed to work on a one to one basis with each of their customers

CRM, when implemented properly, can serve as a multitasking technology that enables the firm to maximize profits and their relationships with their customers.

Multimedia is one of the most fascinating and fastest growing areas in the field of information technology. Text, pictures, animation, movies and sound - all these varied media are seamlessly blended, resulting in simple slide shows to dazzling, interactive presentations. Before the advent of computers, multimedia projects were difficult to put together. Computers enable to combine the media and can be stored for reuse. Multimedia is widely used in entertainment and education.

Mobile multimedia systems reap the power of numerous technologies to bring new features to your fingertips. Through the integration of computers and telecommunications—mobile multimedia is quickly bringing functions like text messaging, graphics and animation, mobile gaming, GPS, personal digital assistant (PDA), localized information, and more to the interior of your vehicle.

This convergence of technologies, similar to what's already happening with home entertainment, personal computers, telephone, Internet and satellite capabilities, will be one of the biggest automotive feature growth areas for years to come. What were once stand-alone features are no longer. Technology harnesses the best parts of individual features, and combines them, delivering capabilities that were once unheard of.

The convergence of computing, multimedia and mobile communications is well underway. Already the familiar voice phone is being transformed into a personal device with a wide range of multimedia capabilities. Soon mobile users will be able to benefit from a broad spectrum of multimedia features and services, to include capturing, sending and receiving images, videos and music.
To deliver such data-heavy, processing-intensive services, portable handheld systems must be optimized for high performance but low power, space and cost.

In response to this need, the MULTIMEDIA APPLICATION PROCESSOR platform from STMicroelectronics is a culmination of breakthroughs in video coding efficiency, inventive algorithms and chip implementation schemes. It will enable smart phones, wireless PDAs, internet appliances and car entertainment systems to play back media content, record pictures and video clips, and perform bidirectional audio-visual communication with other systems in real time.

The ST Application processor focuses on the essential features to meet the future needs of mobile products and services: a high-performance multimedia capability coupled with low power consumption, and based on an open platform strategy.

The new multimedia functionality of mobile products brings with it an increase in power consumption that is outpacing advances in battery technology. It should save on power by avoiding the need for high clock speeds wherever possible, but extremely low power consumption results from a systematic effort at all design levels to reduce power requirements.

The application processor should feature low power smart accelerators which should handle all audio and video functions. These free the main CPU for control and program flow tasks, or allow the CPU to enter power-saving modes to prolong battery life. The smart accelerators operate independently and concurrently to ensure the lowest absolute system power and deterministic high-performance.

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1.1 Customer relationship management

CRM (customer relationship management) is an information industry term for methodologies, software, and usually Internet capabilities that help an enterprise manage customer relationships in an organized way. For example, an enterprise might build a database about its customers that described relationships in sufficient detail so that management, salespeople, people providing service, and perhaps the customer directly could access information, match customer needs with product plans and offerings, remind customers of service requirements, know what other products a customer had purchased, and so forth.

CRM consists of helping an enterprise to enable its marketing departments to identify and target their best customers, manage marketing campaigns with clear goals and objectives, and generate quality leads for the sales team .It assists the organization to improve telesales, account, and sales management by optimizing information shared by multiple employees, and streamlining existing processes (for example, taking orders using mobile devices).

It also allows the formation of individualized relationships with customers, with the aim of improving customer satisfaction and maximizing profits; identifying the most profitable customers and providing them the highest level of service.

1.1.1 Why CRM?

- Improving the process to communicate with the right customers
- Providing the right offer for each customer
- Providing the right offer through the right channel for each customer

- Providing the right offer at the right time for each customer

By doing this, organizations can receive the following benefits [5]:

i. *Creating value for the customer*

Acquiring the right customers based on knowledge or learned characteristics, which drive growth and increased margins.

ii. *Higher customer profitability*

Increasing individual customer margins while offering the right product at the right time.

iii. *Increased customer retention and loyalty*

Ability to retain loyal and profitable customers to increase the organization's profitability.

iv. *Increased revenue*

Focus the sales force on increasing organizational revenues through better information and better incentives to drive top line growth.

v. *Improve global forecast and pipeline management*

Improve information access, forecasting and pipeline management to improve organization's ability to close deals.

vi. *Improve win probability*

Improve the focus of organizational sales efforts with better information to close deals.

vii. *Reduce cost of sales*

New technologies can lower the cost of deploying sales automation solutions and at the same time improve the effectiveness of organizational sales efforts.

viii. Increase sales representative productivity

Reduce the steps involved in tracking and quoting customer data with integration of sales capabilities across the organization.

xi. Promote sales representative retention

Empower organizational sales force to proactively track and monitor their performance and compensation levels to better motivate them to achieve goals and be successful within their positions and for the organization. (Ibid)

1.1.2 CRM Phases [5]

ACQUIRING : A company acquire new customers by promoting their product and service leadership . Company demonstrate how their firm redefines the industry‘s performance boundaries with respect to convenience and innovation. The value proposition to the customer is the offer of a superior product backed by excellent service.

ENHANCING: Company enhance the relationship by encouraging excellence in cross selling and up selling there by deepening and broadening the relationship. The value proposition to the customer is an offer of greater convenience at low cost.

RETAINING : Retention focuses on service adaptability delivering not what the market wants but what customers want .The value proposition to the customer is an offer of a proactive relationship that works in his or her best interest. Nowadays leading companies focus on retention much more than on attracting new customers. The reasoning behind this strategy is simple- if you want to make money hold onto your good customers .

1.1.3 Objectives of CRM [5]

CRM objectives can be divided into four categories as described below:

A. Customer knowledge:

i. Collecting appropriate customer information
ii. Analyzing customer data
iii. Acquiring new customer s
iv. Improving skills of employee
v. Improving CRM technique
vi. Secure service

B. Customer interaction:

i. Appropriate response to customer request
ii. Integration of business processes
iii. Improving channels management
iv. Maximizing the effectiveness and efficiency of organization operations
v. Customizing products and services

C. Customer value:

i. Improving customer retention
ii. Profits increase
iii. Improving customer service and support
iv. Building an attractive virtual community

D. Customer satisfaction:

i. Improving service quality
ii. Establishing relationships with customers

1.1.4 Managing customer relationships[16]

In this section we will deal with the management of customer relationships within an organization .To begin with, theories concerning CRM implementation are done. Secondly, CRM initiatives are discussed.

The ideal CRM organization

There are three essential insights to getting customer relationships right:

i. That building CRM in the front office is just the start, and that it must involve the back office functions like manufacturing, fulfillment, and billing as well as the analytical functions like data warehousing and pushing customer insights back up to the front office.

ii. That conducting relationships across multiple media requires the correct technical infrastructure, allowing companies to deal with their customers in a consistent way across multiple media, and even add new media as required without the need to develop every interface separately and from scratch.

iii. Building the correct strategy for directing customers to different media. For a few organizations the strategy "we will deal with customers on whatever medium they prefer" is right; but for the vast majority of organizations it is a recipe for disaster.

Getting it right in CRM across multiple channels means that you can deal with customers in and across multiple media and still have a unified up-to-date view of the customer, with no gaps . Ideals such as one-to-one marketing and the market one have been widely written about but rarely realized, except in the occasional corner florist's. Getting CRM right is the closest approach to achieving these ideals that a large organization can make. Doing this across multiple media is a major achievement that will make the organization ready to face the future.

1.1.5 CRM virtuous triangle[27]

In CRM, there is a "virtuous triangle". The purpose of this is to ensure that organizations know their customer fully, and then act according to their needs and the organization's interest. Important information is generated and used in other areas. Any company that is doing CRM properly must integrate the front office, the back office, and analytical systems.

• The back office executes the customer requirements. Generally the only customer contact functions in the back office are billing and logistics, and in even these functions, the customer contact is moving into the front office environment.

• Analytical software allows the organization to look for patterns in the customer data which they have collected. The outputs from this are strategic and tactical information. The strategic information can be used to determine future strategy, while the tactical information will help to modify existing practice. Increasingly the tactical information is generated and used on the fly in customer interactions.

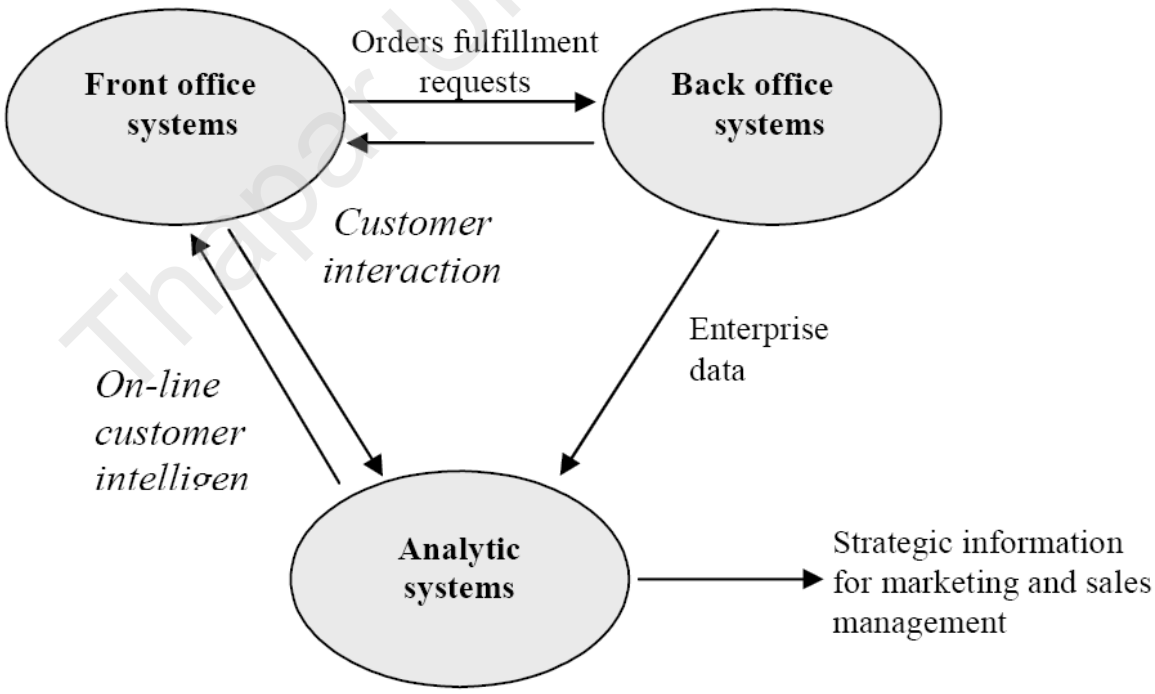


Figure 1.1 Virtuous Triangle Of CRM [23]

1.1.6 Ten ways to initiate or improve your CRM[27]

CRM is a business strategy, which requires planning, commitment and change, and any employee that has any point of contact with a customer at any time should be considered a "CRM user".

Excellence in CRM is not achieved with a software product or a marketing campaign. However, technology such as telephone systems and Web sites can be used wherever it aids a CRM strategy.

Below, ten ways to improve or initiate a CRM program is stated:

i. Defining CRM

The heart of CRM is about knowing your customers and the way they want to interact. CRM is about marketing and customer knowledge, not about great software. CRM can have a wide scope, but it can also be as simple as managing your activities and keeping your promises.

ii. Top management commitment

CRM defines what is happening in an organization so CEOs can move in several areas with more business intelligence. CEO and board commitment is also a critical factor that influences the impact of CRM initiatives and diminishes resistant to change. To state it simply, if a CRM strategy is simple and sanctioned by the CEO, it will probably work.

iii. Staff involvement

The biggest problem with CRM is that it requires staff to capture more data to do more things. Some employees dislike the way that it slows them down and if they have not been shown the value, they reject it. Organizations must get CRM users excited and start with a couple of key supporters. The employees

need to be assured that if they put information into CRM systems they will get value out of it.

iv. Integration of CRM systems

Different people in an organization have different views of the same customer. The marketer might think, “he keeps buying, we need to keep selling to him” while the financial manager thinks, “he is not paying his bills, we will have to stop selling to him”. This is why you need to identify customers and why CRM systems need to be integrated. Furthermore, if customer data does not easily reveal which customers bring in value, it can be too late to adapt marketing practices once the information is realized. Successful CRM is about having real time access to the right information.

v. Research CRM tools and technologies

It is important to spend time researching the IT market to find the tools and technologies appropriate for the organization. Customer relationship tools in the mid-90s did not include SMS messaging, the Internet, or digital phones. There was only mail and fax. However, now you have got interactive TV, interactive Web, digital telephony systems, and e-mail. It is a learning curve.

vi. Long-term view

Some organizations benefit from expensive and complex high-end CRM systems. Those systems can take a long time to roll out and require consultant input. In this case, management must be patient and look at the big picture in the long-term instead of just focus on short-term costs. It is all about what the organization needs, if you do not have a vision behind the sticker price, you are in trouble.

vii. Manage consultant and vendor relationships

Although consultant and vendor relationships can be fractious and expensive, these partners are often the only one that can see the “bigger picture”. It is

therefore important for organizations to manage the relationships and develop mutually reasonable expectations.

viii. Measure the success of your CRM strategy, but be patient

It may take time for a CRM strategy to show return. Often organizations will spend a lot of money in CRM, but not allocate a budget to change culture or establish training. So they regroup and sometimes there is a lot of trial and error. CRM is not a five-minute wonder. Sometimes it takes decades for return on investment to come in.

xi. Keep it simple

While IT people need to help with technical CRM decisions, each investment should have a business requirement. Remove what the organization do not need and implement CRM systems where they add value for users before trying to add value to the organization. A big system might take two years to roll out and then suddenly the organization's requirements and directions have changed. Also remember that CRM needs can differ between departments.

x. Outsourcing

If the organization does not feel up to the CRM learning curve, consider outsourcing. Outsourcers will often recruit, train, and manage contact centers on behalf of clients. The customer does not care about where the person they are talking to is sitting as long as their needs are met. Today, outsourcers that get customer information which they sell back to the organization or uses to manage CRM for the organization are becoming more and more common.

1.1.7 CRM initiatives[10]

The companies who purchases CRM products have a variety of tactics in mind for increasing customer value and loyalty such as *cross-selling and up-selling,*

customer retention, behavior prediction, customer profitability and value modeling, channel optimization, personalization, and event-based marketing.

i) Cross-selling and up-selling

The art of cross-selling and up-selling is understanding which products will increase, rather than decrease, a customer's overall profitability. Up-selling means motivating an existing customer to trade up to more profitable products and cross-selling is the act of selling a product to a customer as a result of another purchase. This has become very popular nowadays, because selling more services to an existing customer increases revenue from that customer and costs less then acquiring a new one .Cross-selling done correctly means selling the right product to the right customer.

It also means understanding that not every customer is a good candidate for cross-selling. Because of this, the desire to improve cross-selling business practices accounts for much of the popularity of CRM marketing automation technologies.

ii) Customer retention

Understanding that customers have left, and knowing specifically who, is non-trivial .Understanding why they have left is even more difficult. Harder yet is stemming the tide of customer attrition by applying this knowledge to business tactics that encourage customers to stay. Analyzing customer attrition operates on the aphorism that keeping an existing customer is far more cost effective than acquiring a new one. After all, the more customers leave, the greater the loss of revenue, loss of initial acquisition investment, and loss of a stable market base for selling new products.

iii) Behavior prediction

Behavior prediction helps companies determine what customers are likely to do in the future .Using sophisticated modeling and data mining techniques

behavior prediction uses historical customer behavior to foresee future behaviors. This analysis includes several variations:

• Propensity-to-buy analysis. Understanding which products a particular customer is likely to purchase.
• Next sequential purchase. Predicting what product a customer is likely to buy next.
• Product affinity analysis. Understanding which products will be purchased with other products. Also known as "market basket analysis" .
• Price elasticity modeling and dynamic pricing. Determining the optimal price for a given product, often for a given customer or customer segment.

iv) Customer profitability and value modeling

Extensive processing and detailed data combined with profitability modeling products have made it possible for organizations to know who of their customers that is worth keeping. Today, organizations can quantify that price-sensitive customers - those who bring in paper-thin margins - might never recoup their value, irrespective of their purchase volume; yet certain low-volume customers were nevertheless highly profitable. However, profitability is only one piece of the revenue puzzle. A customer can be unprofitable but could have referred three high-value customers to your organization, thereby rendering him very valuable.

v) Channel optimization

The goal of marketing automation is to offer the right product to the right customer at the right time. With the advent of Internet, many organizations are appending "through the right channel", as customers´ interaction preference evolve. However, understanding the channels through which specific customers prefer to interact with your company is only a slice of the pie. Organizations must also decide how to best communicate with its customers. Channel management means optimizing an organization's "inbound" channels with its

"outbound" means of customer interaction and knowing how to choose the best approach for each.

vi) Personalization

Personalization is the capability to customize customer communication based on knowledge preferences and behaviors at the time of interaction. Personalization, as most people see it, is online messages tailored to a particular customer or customer segment. Such tailored messages can involve anything from inserting the Web shopper's name into the message – known as variable insertion – to using detailed customer data to personalize Web site content. More specifically, personalization technologies can tailor messages to individual customers, accessing current personal data each time the customer visits the Web site and using it to create custom content.

vii) Event-based marketing

The best definition of event-based marketing is time-sensitive marketing or sales communication reacting to a customer-specific event. Event-based marketing, also called event-driven-marketing, can apply to a segment of customers or to individual customers. However, it is the individual event-based marketing that organizations adopting CRM are striving for. They want to move beyond traditional, carefully choreographed and scheduled marketing campaigns to more reactive, real-time customer communications highly focused on the individual customer's profile.

1.2 Multimedia Application Framework

1.2.1 Multimedia framework definition[23]

A multimedia framework is a software structure (usually a set of software libraries) that handles media on a computer and through a network. A good multimedia framework must offer an intuitive API and a modular architecture to easily add support for new codec or container formats. It is meant to be used

by applications such as media players and audio or video editors. Figure 1-1 depicts a high level architecture view to indicate how a multimedia framework is integrated in a rich OS.

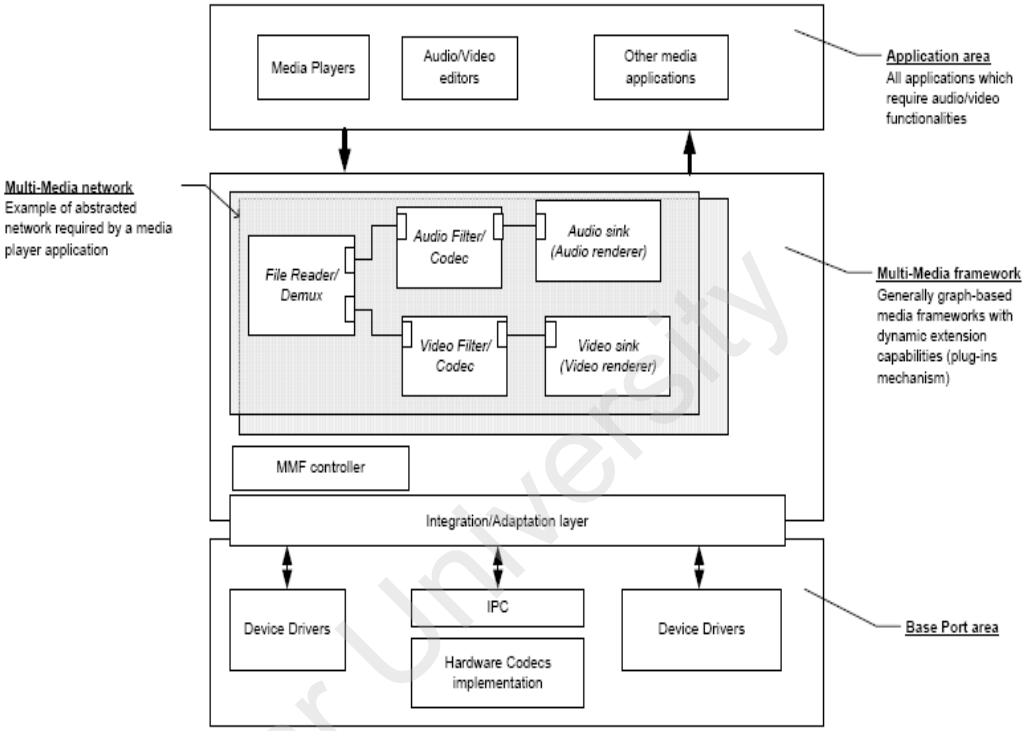


Figure 1.2 Multimedia Framework[23]

A multimedia application is abstracted from the underlying hardware via the proposed multimedia framework. Sink/source pads or other filter/codec components abstract I/O devices and transforms through the adaptation layer and derived drivers. The different frameworks search to reach the following characteristics:

• Defines an architectural framework for multimedia applications (Audio/Video & Imaging)
• Abstracts multimedia content handling (file type, streaming).
• Hides device complexities.

• Provides easy interface to audio/video playback/recording and control.

• Provides building blocks and advanced features for application like games, media players.

• Enables development of new media extensions as plug-ins.

• Allows dynamic, automatic media type detection.

ST-based solutions are designed to target the mobile phones and mobile consumer devices. The SW offering covers in priority the following OS MM frameworks:

• MMF (Symbian OS)

• DirectShow (Windows Mobile)

• GStreamer (embedded Linux)

The variability and the level of maturity of these diverse native frameworks mean that there is different level of abstraction, flexibility and design constraints. A client (user/media application) can have a constrained or a fully opened environment to build a multimedia solution. Consequently, the SW designer/integrator can have more or less facility to integrate a new feature and to take accounts in the same time an advanced distributed multimedia HW and SW architectures.

In particular, each framework provides different integration scheme to abstract the underlying hardware/system. OpenMAX Integration Layer initiative tries to resolve this last issue. It serves as a low-level interface for audio, video and imaging components used in embedded and/or mobile devices.

1.3 Multimedia Application Processor [22]

1.3.1 Application processor multimedia resources

Application processor -based solutions are designed to target the mobile phones and mobile consumer devices. The Application processor SoC family is based on a multicore approach with dedicated and programmable HW blocks (Smart

Media Accelerator). It provides an efficient and consistent HW/SW partitioning to achieve high performances for the complex multimedia use-cases and to minimize the global power consumption. The main goal is to maximize the ratio “computing performance” on “energy”. A general purpose CPU (host CPU) provides the required functionalities to support a rich OS like Symbian, Linux or Windows Mobile. The accelerators (SxA) supply a HW or/and SW support to speed up processing of some specialized media functions.

All HW resources are accessible and fully controlled by the host CPU .The IO peripherals can be also mapped in the main controller space but only a limited number of interrupt and local DMA request lines are routed to/from the main cores. DMA system is only programmable by the host CPU but each SxA subsystem controls the dedicated system DMA request lines.

1.3.2 Application processor memory model

The memory model for Multimedia Application Processor has the following properties:

• Not Cache Coherency – Non-Uniform Memory Access
• Non-uniform virtual memory space & non global memory protection
• Unified sub-system architecture

1.3.3 Application processor multimedia framework architecture

This section describes the top level architecture of the proposal Application Processor Multimedia Framework. The main purpose is to provide a flexible way to use efficiently the multimedia resources (SxAs and related HW resources) and to export a logical view of the Processor’s multimedia functionalities for the multimedia clients

This architecture provides a low-level multimedia framework to:
• Hide the complexity/specificity of the underlying hardware.

• Take advantage of platform specific features.

• Provide a minimum level of abstraction for multimedia application servers above it.

Below Figure describes the architecture of Application Processor MMF

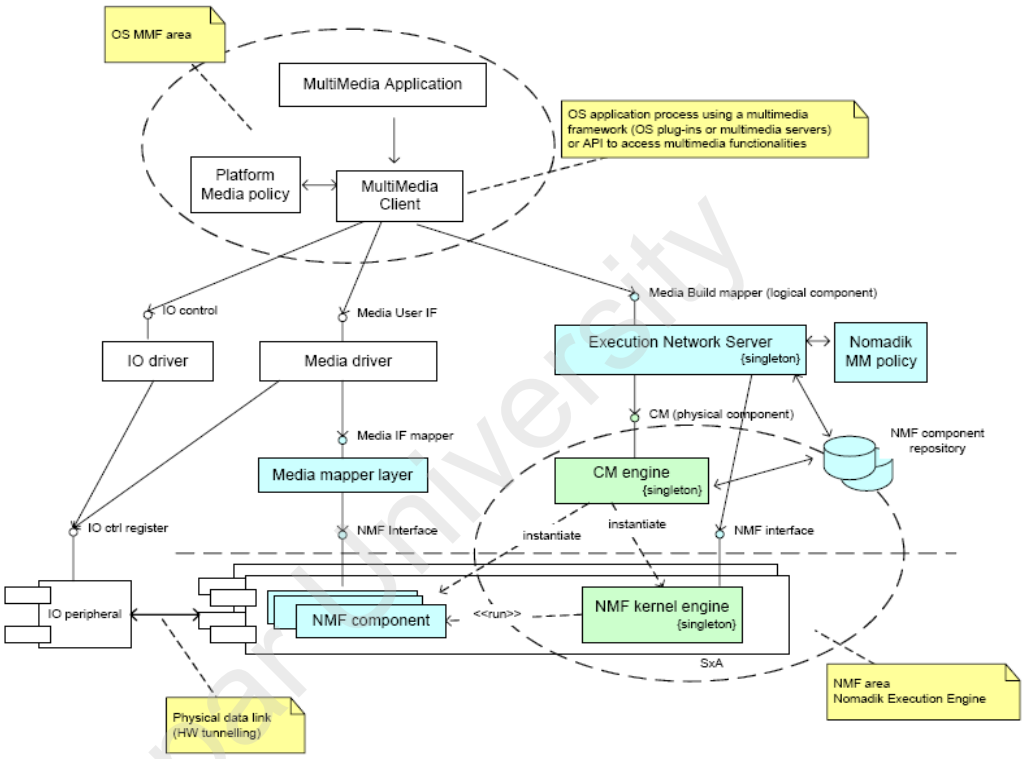


Figure 1.3:**Architecture Application Processor MMF[23]**

The key idea is to provide a single low level multimedia interface to allocate and to control/instantiate the multimedia resources. To be efficient for demanding use cases, the other important point is to separate the control and the data flow [9]. The optimization of the data path is crucial. It consists of both the classical data transfer mechanism, such as shared memory or DMA transfers, and data signaling. The control path is a low latency process without real time constraint. It is not involved in the application data transfers. The purpose is to have a central component to merge/combine the different user requests from the multimedia/application network

servers and to deal with the different Logical multimedia networks (or logical multimedia graphs).

An appropriate dynamic resource management, the Network server decides to instantiate physically the appropriated components to perform the requested multimedia functionalities. Media Build mapper exports an API to manipulate and to create the logical graphs. Each node is associated to a logical multimedia functionality manipulated by the upper layer. IO peripherals are controlled through "standard" OS drivers. Multimedia client or the media drivers are responsible to forward the configuration of the different ports. The network server provides the relevant information to take the appropriate and final decision to stop or to install a new multimedia service.

1.4 Introduction to ST application processor [23]

ST Application Processor family of multimedia application processor chips enable portable terminals to play music, take pictures, record video and host two-way visual communications in real time. They are aimed a 2.5G/3G mobile phones, personal digital assistants and other portable wireless products with multimedia capability. In addition they are suitable for automotive multimedia applications.

ST Application Processor is designed specifically with mobile devices in mind, offering ultra low power consumption, unsurpassed audio and video quality at given bit rates, simplified software development and scalability for diverse and future multimedia applications. The following described is ARM processor which is embedded on the

1.4.1 ARM Processor

The current deep submicron technology era presents two opposing challenges: rising SoC platform development costs and shorter product market windows. The rising platform development costs are due to four main sources: the continued rise in gate

count, the emergence of deep submicron effects, the rising proportion of embedded software development costs, and finally, rising mask set costs.

As a result, the significant investment to develop the platform requires to maximize the *time-in-market* for a given platform. On the other hand, the consumer-led product cycles imply increasingly shorter *time-to-market* for the applications supported by the platform. Addressing these two conflicting requirements will come from the development of more flexible platforms that can be used across a wider range of applications and can evolve with short-term market requirements

Next-generation mobile systems are bound to these same commercial realities. Moreover, competition is extremely high which causes extreme pressure on costs. Differentiation is increasingly coming from the ability to offer distinctive functionality quickly. Multimedia functions such as enhanced audio, video recording and playback, digital still imaging and 3D graphics are becoming stronger and stronger mandatory features in this market. Providing advanced multimedia functions at low power requires the effective use of parallelism. The use of multiple low-frequency, simple processors is a more power effective means of delivering a specific performance target than a single, high-speed processor with deep pipelines, branch prediction and complex memory hierarchies.

1.4.2 Functional blocks

The ST application processor comprises the following functional blocks whose details have been studied from [25]

ARM

This is a cached ARM CPU including *Memory Management Unit* (MMU) and Instruction plus data caches.

Embedded Trace Macro cell

The ETM provides a trace port for real-time debug, and support 4-bit and 8-bit normal trace mode and 4-bit de-multiplexed trace mode, with normal or half-rate clock.

Vectored Interrupt Controller (VIC)

The VIC allows the OS interrupt handler to quickly dispatch interrupt service routines in response to peripheral interrupts.

Direct Memory Access Controller (DMA)

Direct memory access can be used with DMA peripherals. FIFO fill/empty requests from these peripherals can be serviced immediately by the DMA Controller without CPU interaction's peripheral-to-peripheral and memory-to-memory DMA are also supported two 8-channel DMA controllers are provided for efficient and concurrent transfers.

System & Reset controller (SRC)

This provides a control interface for clock generation components external to the subsystem. It also controls system-wide and peripherals-specific energy management features.

Real Time Clock (RTC)

The RTC provides a one second resolution clock. This keeps time when the system is inactive and can be used to wake the system up when a programmed 'alarm' time is reached. It has a clock trimming feature to compensate the drift of the 32.768 kHz crystal, and a secured time update.

Watchdog Timer (WDT)

This OS resource is used to trigger a system reset in the event of software failure.

Universal Asynchronous Receivers-Transmitters (UARTs)

The ST application processor provides three Auto baud UARTs.One offers all modem control/ status signals. They are enhanced version of the industry-standard 16C550 UART.

Synchronous Serial Port (SSP)

The ST application processor provides one SSP, for synchronous serial communication with external peripherals SPI, Micro Wire, T.I.and mono-directional protocols are supported with programmable word length up to 32 bits.

Synchronous Serial Interface (SSI)

This interface is composed of one transmitter and one receiver that perform high-speed serial data exchange on a pair of differential lines.

1.4.3 Architecture

The ST application processor architecture is based on an ARM processor connected through a Multi-Layer Advanced Microcontroller Bus Architecture (AMBA)

infrastructure to a rich and powerful set of peripherals. The architecture of the system and the peripherals mix chosen has been based on two factors:

i) to provide minimal support for high-level operating system such as Symbian and WinCE Operating Systems (OSs).

ii) to support the required set of external interfaces for portable multimedia application, such as LCDs, Multimedia Cards, SD-Cards, audio codecs.

The aim of providing minimal support is to enable system integrators maximum flexibility in product differentiation, while balancing the design reuse productivity gains afforded by higher level OS support. Consideration has been given to minimization of area (gate count) and power-consumption, with four different operational modes that allow to optimize the power consumption to extend the battery life.

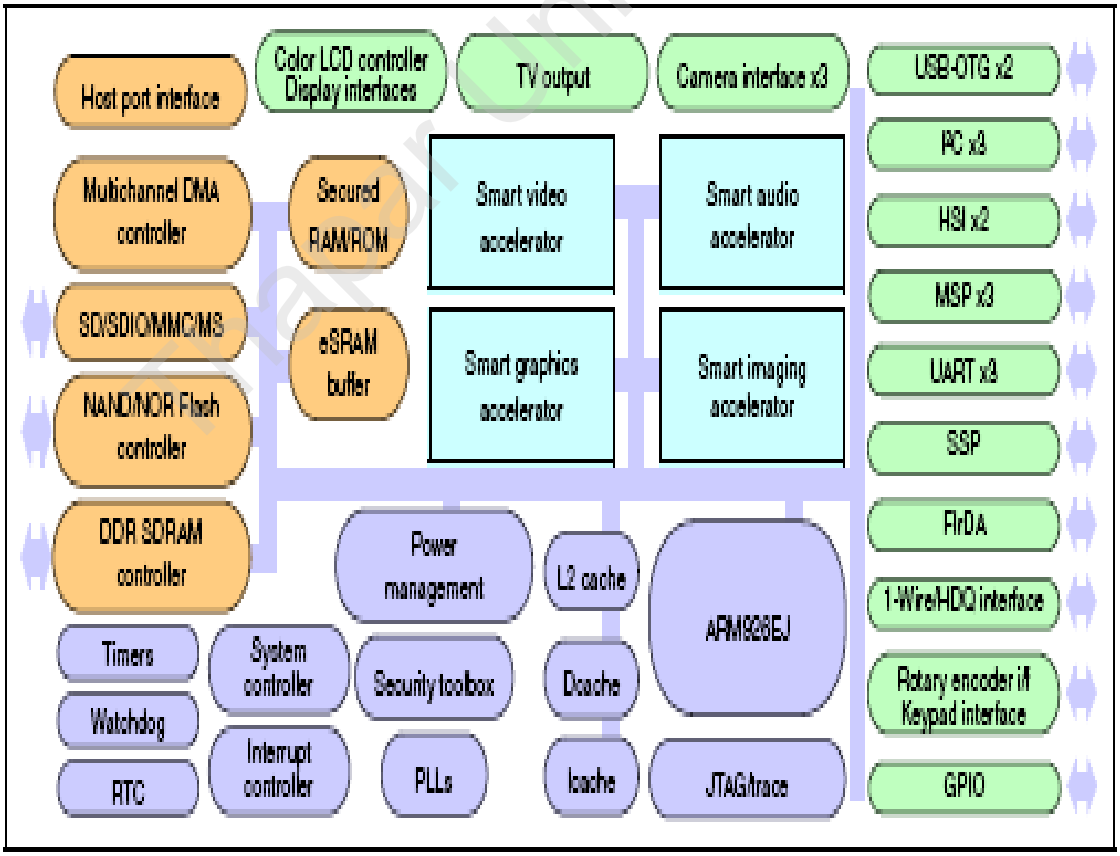


Figure 1.4 Architecture[25]

Interrupt System

The ST application processor has an Vectored Interrupt Controller (VIC) that provides software interface to the interrupt system. In ARM system, two levels of interrupt are available:

Fast Interrupt Request (FIQ) for fast, low latency interrupt handling Interrupt Request (IRQ) for more general interrupts. Only a single FIQ source at a time is generally used in a system, to provide a true low latency interrupt. This has the following benefits: You can execute the interrupt service routine directly without determining the source of the interrupt. Interrupt latency is reduced. We can use the banked registers available for FIQ interrupts more efficiently, because a context save is not required. There are up to 64 interrupt lines managed by the Vectored Interrupt Controller. The VIC uses a bit position for each different interrupt source. The software can control each request line to generate software interrupts.

There are 16 vectored interrupts. These interrupts can only generate an IRQ interrupt. The vectored and non-vectored IRQ interrupts provide an address for an Interrupt Service Routine (ISR).Reading from the vector interrupt address register, VIC_VAR, provides the address of the ISR, and updates the interrupt priority hardware that masks out the current and any lower priority interrupt requests. Writing to the VIC_VAR register indicates to the interrupt priority hardware that the current interrupt is serviced; allowing lower priority interrupts to go active. The FIQ interrupt has the highest priority, followed by interrupt vector 0 to interrupt vector15. Non-vectored IRQ interrupts have the lowest priority. The priority of the FIQ over IRQ is set by the ARM. The VIC can raise both a FIQ and an IRQ at the same time .The IRQ and FIQ request logic has an asynchronous path. This allows interrupts to be asserted when the clock is disabled.

CHAPTER 2 : Literature Review

Review of literature is very important as it helps in placing the study in proper perspective, learn from the mistakes of the predecessors and avoid the duplication of work.

For Review of Literature the following pattern is used:

2.1 Review of Studies done on CRM

2.2 Case study I of CDON.com

2.3 Case study II of Semiconductor and electronic device manufacturer

The analysis of the case helps in understanding the importance of CRM and sets the stage for the implementation of CRM strategies by developing a multimedia tool to assist the mobile companies to be market leaders in Implementing CRM strategies.

2.1 Review of studies done on CRM

The study by Kapanen (2004) highlights that organizations are realizing that customer-centric operations are no longer an optional differentiator, but are essential to sustainable, profitable growth. Customer relationship management, or CRM, is a framework for developing both the business processes and the supporting infrastructure to improve service delivery. CRM solutions focus on automating and improving business processes in front-office areas such as marketing, sales, customer service and support. CRM software and hardware is only part of the solution, as the people, processes, management and reward systems must be included to successfully implement a CRM solution. CRM aims to improve organizational effectiveness by establishing the following: a single, dynamic, clear understanding of the customer, from the company's perspective, across different departments of an organization; a single, dynamic, clear understanding of the company, from the customer's perspective, regardless of communication channel utilized (personal meeting, telephone, internet); and improved communication, coordination and efficiency across marketing, sales, service and support departments, within an organization. The intended results are improving customer satisfaction, loyalty, and retention. These results lead to

improved profitability from both increased revenues and reduced costs. This paper focuses upon CRM improving service delivery, and not enterprise resource planning (ERP). ERP applications have helped companies to automate and optimize business processes in areas such as finance, manufacturing, inventory management and human resources. ERP is different, but supportive, of CRM.

Greve, Robert A et al (2005) study the impact of routing strategies and prioritization of incoming e-mail messages on CRM objectives of an organization. Customer contact centers represent a growing industry in which Customer Relationship Management (CRM) applications have been developed and used successfully. Customer call centers, a multi-billion dollar industry, are evolving into customer contact centers, which now include channels of communication other than the telephone. E-mail, a popular alternative to the telephone for all types of communication, is becoming a common medium for customer contact. CRM applications currently exist that allow us to implement and monitor e-mail management strategies. For example, incoming e-mail can be automatically routed to specific customer service agents according to predefined routing rules. The routing mechanisms available in the software tools are heuristic, and not based upon any scientific analysis of the performance of different routing policy alternatives. The objective of this paper is to create a model representative of and consistent with e-mail response centers in industry. The process modeled was corroborated by a domain expert. A comprehensive simulation study is conducted to analyze different routing policies and prioritization options. The results of the simulation study indicate that specific routing strategies and the use of specific priority schemes by the e-mail agent can result in a significant improvement in the response centre's performance, as indicated by average response times and average resolution times of different categories of e-mail messages. Although call centre operations have been studied extensively, this study shows that performance of contact centers needs further investigation because of the greater flexibility that exists in the assignment and scheduling of e-mail processing tasks.

All these studies highlight the importance of CRM in the digitalized world we are living in today and the importance of CRM for organizations to acquire enhance and retain the customers now moving on to the case study.

2.2 Case study I – CDON.COM

Company presentation

CDON.COM is the address to the electronic online market place run by MTG Internet Retailing AB. CDON.COM today sells entertainment products in 16 countries and has 52 employees. The annual turnover for 2007 was 602 Million. The organization MTG Internet Retailing is based in Malmo, Sweden, and is a part of MTG (Modern Times Group). MTG is a leading media group in the Nordic countries and the Baltic States and operates within TV, radio, newspapers, electronic retailing and other media related services. MTG is listed on the Stockholm stock exchange's O-list and on the NASDAQ stock exchange in NYC[28]. CDON.COM used to offer more than 100000 titles in four product categories which were music, movies, books, as well as computer games and video games. But now they have only one category which is music.

2.2.1 CDON.COM´s CRM objectives

The term CRM is not used when discussing customer relationships within the organization. However, CDON.COM is a customer oriented organization that focuses on the customer's needs. Just because the term CRM is not used in the daily work it does not mean that CDON.COM does not practice CRM as defined in this study. CDON.COM would not exist without their customers and therefore the organization must focus on the customers' needs and interests at all levels of the organization. This means that every organizational objective also can be seen as a CRM objective. However, the most important thing is not to have a lot of different objectives. The most important thing is what you actually do and how you act when interacting with the customers. CDON.COM has three main objectives or areas where they constantly are trying to improve.
The first objective is very important when it comes to attracting customer to the Web site[28]. Because of the fact that CDON.COM sells the same products as their competitors, price is a very important factor when trying to attract

customers to the Web Site. This combined with massive marketing campaigns to build awareness among potential customers is absolutely crucial for the organization to survive in the comparatively new and competitive e-business market. The second objective means that it should be an interesting and a potential retailer for almost every person that are interested in the offered product categories CDs, movies, and games. However, not all potential customers are worth going for because of cost reasons but that they are trying to reach as many as possible.

The third objective is simplicity and ease of use which basically means that when a customer visits the Web Site he or she should be able to buy or search for whatever he or she wants without experiencing any problems or delays. How fast a visitor is able to download and navigate the Web site is much more important than having a lot of animations and 3D graphics that would add value to the Web site but also make it a lot slower for many of the users. It is also important that it is easy to log in and shop at the Web site as well as that delivery works as promised to the customers [28]. When it comes to customer service it has stated that incoming e-mails should be answered within 24 hours.

The reason why these three objectives are especially important is because this is what is most important when conducting e-business for the products that it offers. The other objectives also are of importance to CDON.COM[28]. However, these objectives are not stated due to cost and time reasons but would be important if the members of the organization had more time to deal with these kinds of issues.

One objective that is of importance is knowledge about the customers. By collecting and analyzing as much data as possible about the customers the organization can make better strategic choices in the future and avoid making mistakes when it comes to almost all business areas. By doing this CDON.COM gets more satisfied and loyal customers and then hopefully

customers that spend more money at their Web site. This is best done by the help of technology but also by the persons working and interacting directly with the customers can help it become more effective.

Another important issue when it comes to customer relationship management in e-Business is security. It is important to convince the customers that it is not more dangerous to pay with a credit card on-line than it is in a regular store. Privacy could also be an issue. However, the products that CDON.COM sells are not very sensitive ones when it comes to privacy so this is not very important to CDON.com. Another issue that also could be of importance is channel management. Some organizations might find it very helpful to collect information from customers about which channel they prefer but this is not an issue or objective for CDON.COM . However, when it comes to logistics it has stated an objective to deliver the products within 2-6 working days[28].

2.2.2 CDON.COM managing their customer relationships

CDON.COM was one of the first in its industry to treat five important business areas as equally important. These areas are marketing, campaign, the Web site, logistics, and customer service. All of these business units should be aware of each other and what the different units are doing. The reason for this integration of business units is to improve the flow of products and services and to be able to correct and avoid mistakes more easily[28]. As mentioned above CRM as a term is not used, instead it views the whole organization as customer oriented.

When it comes to the management of customer relationships Top management involvement and staff involvement as crucially important . All members of the staff must have the customer in mind when decisions are made and to make this work the top management must be good role models. All departments have access to the collected customer data, which leads to shorter decision making

time and also make the staff feel more involved. It is also important to have a long-term view to retain the customers for a long time. However, this can sometimes be hard when selling commodities such as DVDs and CDs where price is very important. To keep thing simple is also very important when managing customer relationship. This is especially true in e-Business where you have to be prepared for technological changes and improvements but you must also look at the costs involved. It is not always worth the costs to make your customers more satisfied and you can not possibly please all of your customers. It is also important to keep things simple when it comes to the Web Site. Speed is much more important than for example providing a very flashy Web site [28].What people want to do is to be able to log in and search for and buy products without hassle and then receive them in time. This is much more important than providing an exciting Web experience which makes the buying process slower.

CDON.COM conducts all of their customer service by themselves and would never consider outsourcing of this area as an option. They think it would be unwise to outsource something which is that important to the organization. CDON.COM only has one customer service department which they want to control totally. By doing this they are as close to the customers as they can be and can benefit from feedback from the customers to people that they trust within the own organization[28]. By having their own customer service department they also get feedback from their customers much faster than they would if someone else handled these issues located at a place far from the headquarter.

CDON.COM recently invested in a new improved search engine and technology which will improve the organizations knowledge about their customers as well as help predicting their future behavior. The organization is today able to predict, or at least try to predict, what the individual customer is going to buy next based on past purchases and the information the customer

provided in an optional form when registering at the Web site for the first time. This new technology also simplifies the process of selling more products to existing customers both related and non-related to previous purchases. One example of this is that if you buy the new James Bond movie you get a discount if you buy the soundtrack. CDON.COM also offer a service named order status where a customer can find a full overview over all of his or her orders and for example find out if the ordered product have been sent or not.

CDON.COM will also implement a newsletter that will be unique for each customer and they will be able to segment their customers on an individual basis. A customer interested in heavy metal will not receive any information about for example a new Britney Spears album which sometimes was the case before. Receiving a lot of information about movies and artist that you are not interested in will only give the customer a negative perception of the organization and make them reluctant to shop at the Web Site. By improving this CDON.COM hopes to get loyal customers that are aware of that they will not be let down when new and important products of interests to the customers are released. They think this is just a waste of time and money and something that the customers do not request or care for.

If you are a loyal customer and frequently purchase products from CDON. COM you can become a VIP member and get discounts for some of their products. this is a good way to reward loyal customers. However, this can not be made too much and too often since the organization already competes with low prices and therefore can not afford much discounts. Another CRM initiative that CDON.COM uses is event marketing where special offers are offered to their customers in connection with a certain event[28]. An example of this can be discounts on the different Madonna CDs for the Swedish customers when she is performing in Sweden.

CDON.COM only uses one communication channel to interact with its customers. This communication channel is e-mail which is the most effective and appropriate one. By using e- mail the staff at the customer department service can handle many customers at the same time which is very cost effective. Since the customers and the staff are not in direct contact when using e-mail it also excludes a lot of noise such as discussions about other things than the real issue. Web chat, Web callback, and telephone could also be used. However, the reason why these communication channels not are of importance is because of the above mentioned noise and that every issue would take longer time to handle by using these channels. When sending an e-mail to the customer department the customer is asked to provide his or her telephone number but the customers are only contacted by telephone in very special and complex occasions[28]. Using all of the so far mentioned communication channels would be a nice service for the customers but would not be cost effective. Using mail as a communication channel is not an option. It simply takes too long time .

2.2.3 CDON.COM evaluating the effectiveness of their CRM

They evaluate some of their customer relationships .However more could absolutely be done but this is a question of resources as well as a somewhat complex issue. The organization do measure the average number of products sold per purchase and the percentage of customers which shop more than once to be able to evaluate if the customers only buys one product at the time and if they come back after the first purchase experience. CDON.COM also frequently measures the speed of downloading and navigating the Web site to make sure that for example layout changes does not make the Web site any slower[28]. Furthermore, CDON.COM measures how many customers that pay with a credit card which is something the organization strive for and the average number of e-mails sent per day to the customer service department. However, CDON.COM does not measure the security level when it comes to

customer payment. E-mails sent to the customer service department are the most important variable when evaluating the effectiveness of the CRM for CDON.COM.

By analyzing the customers' requests, suggestions, and complaints the organization receives a lot of feedback and valuable information on how to improve their business. Also the quality of the staffs' answers of the e-mails are controlled and evaluated to find out if they satisfies and solves the customers' requests and problems[28]. Furthermore, a survey is sent out to the customer every sixth month where the organization is trying to find out what the customers like and dislike about the Web site when it comes to product mix, navigation of the Web site, and the Web site environment.

CDON.COM also evaluates some logistic measures to be able to find out if they keep their promises to their customers when it comes to delivering the products within 2-6 working days and to be able to find out what they need to do to improve their logistics.CDON.COM frequently check that their technological capacity is enough to serve their customers which is connected to the downloading and navigation time measures of the Web site. Marketing efforts are also evaluated when it comes to cost per acquired customer but no awareness measures or brand image measures are yet measured and evaluated.

CDON.COM measure how many people that visits the Web site when it comes to unique visitor count as well as how many people that registers as customers[28]. These measures is also tied to net sales, profit increase, and market share which shows how much CDON.COM grows from time to time when measured which is very important at this stage for CDON.COM.

2.3 Case study II : Semiconductor and electronic goods manufacturer (ST Microelectronics)

2.3.1 Company Presentation

STMicroelectronics is a global independent semiconductor company and is a leader in developing and delivering semiconductor solutions across the spectrum of microelectronics applications. An unrivaled combination of silicon and system expertise, manufacturing strength, Intellectual Property (IP) portfolio and strategic partners positions the Company at the forefront of System-on-Chip *(SoC)* technology and its products play a key role in enabling today's convergence trends.[28]

According to preliminary rankings for 2002 from market analysts, ST was placed among the top five semiconductor manufacturers worldwide for the second year running. Gartner Dataquest ranked ST as the fourth largest semiconductor company in the world and IC Insights and Supply ranked the Company fourth and third, respectively. According to the most recent data from independent sources, ST is also the world's leading supplier of analog ICs and MPEG-2 decoder ICs, and is ranked number two for non-volatile memories overall and at number four for Flash memory. In application segments ST is number one for ICs for set-top boxes and hard disk drives; at number two for smart cards and DVDs; at number three for automotive ICs; and finally, at number four for telecom ICs.

The Company's products are manufactured and designed using a broad range of fabrication processes and proprietary design methods. To complement this depth and diversity of process and design technology, the Company also possesses a broad intellectual property portfolio that it has used to enter into cross-licensing agreements with many other leading semiconductor manufacturers.

ST has developed a worldwide network of strategic alliances, including product development with key customers, technology development with customers and other semiconductor manufacturers, and equipment and CAD development alliances with major suppliers. By augmenting its rich portfolio of proprietary technologies and core competencies with complementary expertise from a variety of carefully chosen

strategic partners, ST has developed an unsurpassed capability to offer leading edge solutions to customers in all segments of the electronics industry.A combination of dedicated, semi-custom and programmable products designed to suit a specific customer or a specific application and therefore having high system content. This result reflects ST's exceptionally early recognition of the importance of system-on-chip technology, which is the key for addressing the fast growing market for convergence products, and the success of the strategies it developed to ensure its leading position in this key emerging field.

The ST group was formed in June 1987 as a result of the merger between *SGS Microelettronica of Italy* and *Thomson Semiconductors of France*. In May 1998, the company changed its name from **SGS-THOMSON Microelectronics** to STMicroelectronics.[28]

Since its formation, the Company has significantly broadened and upgraded its range of products and technologies and has strengthened its manufacturing and distribution capabilities in Europe, North America, and the Asia Pacific region. This capacity expansion is an ongoing process with the upgrading of existing facilities and the creation of new 8-inch, sub-micron fabs around the world. ST currently has five 8-inch fabs in operation in: Rousset (France); Agrate Brianza, R2 (Italy); Crolles (France); Phoenix (Arizona); and Catania (Italy). In addition, a sixth 8-inch fab is currently ramping up in Singapore. Furthermore, a new 12-inch manufacturing facility is currently under construction in Catania and the company is now close to completing a 12-inch pilot line called Crolles2, in partnership with the semiconductor arms of Philips and Motorola[28]. The Crolles2 operation is also host to the joint development program between the three companies to develop leading-edge CMOS process technology down to the 32nm node, in conjunction with TSMC for process alignment.

2.3.2 VIC – Vectored Interrupt Controller

A vectored interrupt controller is a hardware device that receives interrupts form multiple sources, and forward the interrupt requests to the processor. It manages the priority between interrupts. Different interrupts lines can be

configured as FIQs, vectored IRQs, or non vectored IRQs depending on the priority and allowed latency. Highest priority is given to the FIQs, followed by the 0-15 vectored IRQs[23]. Non-vectored IRQ interrupts lines have the lowest priority .The VIC provides an interface to the interrupt system, and improves interrupt latency in two ways:

• moves the interrupt controller to the AMBA AHB bus
• provides vectored interrupt support for high-priority interrupt sources.

The VIC provides a software interface to the interrupt system. In a system with an interrupt controller, software must determine the source that is requesting service and where its service routine is loaded. A VIC does both of these in hardware. It supplies the starting address, or vector address, of the service routine corresponding to the highest priority requesting interrupt source.

The VIC does not handle interrupt sources with transient behavior. For example, an interrupt is asserted and then de-asserted before software can clear the interrupt source. In this case, the CPU acknowledges the interrupt and obtains the vectored address for the interrupt from the VIC, assuming that no other interrupt has occurred to overwrite the vectored address. However, when a transient interrupt occurs, the priority logic of the VIC is not set, and lower priority interrupts can interrupt the transient interrupt service routine, assuming interrupt nesting is permitted. There are 32 interrupt lines. The VIC uses a bit position for each different interrupt source. The software can control each request line to generate software interrupts.

2.3.3 Features of the VIC

The VIC has the following features[23]:

• compliance to the AMBA Specification (Rev 2.0) onwards for easy integration into SoC implementation

• support for 32 standard interrupts

• support for 16 vectored IRQ interrupts

• hardware interrupt priority

• IRQ and FIQ generation

• AHB mapped for faster interrupt response

• software interrupt generation

• test registers

• raw interrupt status

• interrupt request status

• interrupt masking

• privileged mode support

• vector interrupt controller daisy-chaining support.

2.3.4 Functional overview

In an ARM system, two levels of interrupt are available[23]:
Fast Interrupt Request (FIQ)
For fast, low latency interrupt handling.
Interrupt Request (IRQ)
For more general interrupts .
Generally, we only use a single FIQ source at a time in a system to provide a true low-latency interrupt. This has the following benefits:

• You can execute the interrupt service routine directly without determining the source of the interrupt.
• It reduces interrupt latency. You can use the banked registers available for FIQ interrupts more efficiently, because you do not require a context save.

The interrupt inputs must be level sensitive, active HIGH, and held asserted until the interrupt service routine clears the interrupt. Edge-triggered interrupts are not compatible There are 16 vectored interrupts. These interrupts can only generate an IRQ interrupt. The vectored and non-vectored IRQ interrupts provide an address for an Interrupt Service Routine (ISR). Reading from the Vector Interrupt Address Register, VICVECTADDR, provides the address of the ISR, and updates the interrupt priority hardware that masks out the current, and any lower priority interrupt requests. Writing to the VICVECTADDR Register indicates to the interrupt priority hardware that the current interrupt is serviced, enabling lower priority or the same priority interrupts to be removed, and for the interrupts to become active to go active.
The FIQ interrupt has the highest priority, followed by interrupt vector 0 to interrupt vector 15. Non-vectored IRQ interrupts have the lowest priority. A programmed interrupt request enables you to generate an interrupt under software control. This register typically downgrades an FIQ interrupt to an IRQ interrupt.

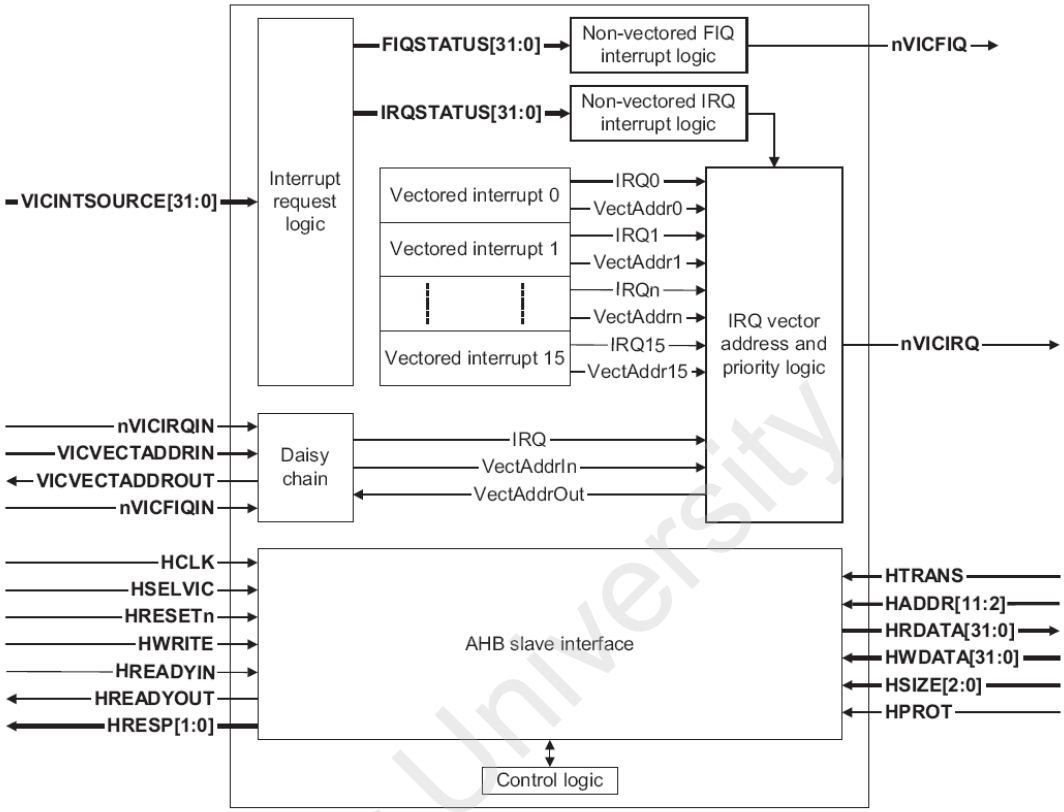


Figure 2.1: ARM Interrupt System[25]

2.3.5 The main components of the VIC:

- *Interrupt request logic*
- *Non-vectored FIQ interrupt logic*
- *Non-vectored IRQ interrupt logic*
- *Vectored interrupt block*
- *Interrupt priority logic*

Interrupt request logic

The interrupt request logic receives the interrupt requests from the peripheral and combines them with the software interrupt requests. It then masks out the interrupt requests that are not enabled, and routes the enabled interrupt requests to either IRQSTATUS or FIQSTATUS. Figure 2-2 shows a block diagram of the interrupt request logic.

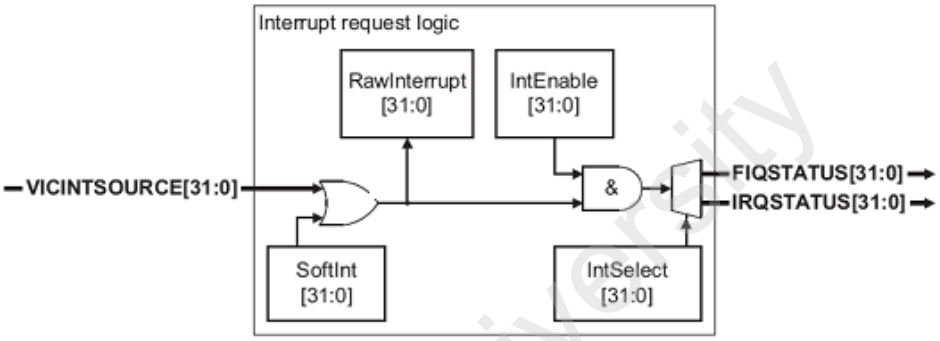


Figure 2.2: Interrupt request logic[25]

Non-vectored FIQ interrupt logic

The non-vectored FIQ interrupt logic generates the FIQ interrupt signal by combining the FIQ interrupt requests in the interrupt controller and any requests from daisy-chained interrupt controllers..

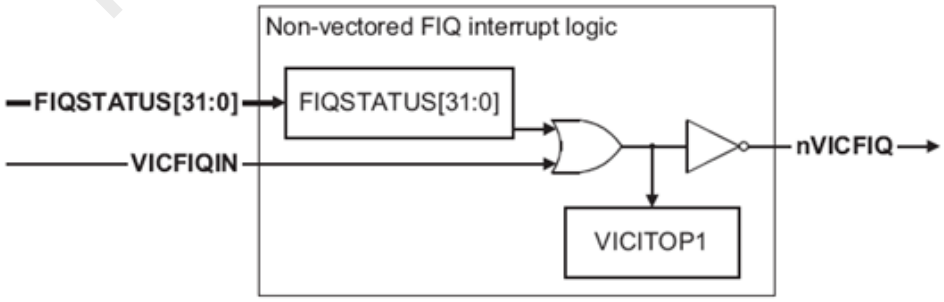


Figure 2.3:Non-vectored FIQ interrupt logic[25]

Non-vectored IRQ interrupt logic

The non-vectored IRQ interrupt logic combines the non-vectored interrupt requests to generate the non-vectored IRQ interrupt signal. This signal is then sent to the IRQ vector address and priority logic.

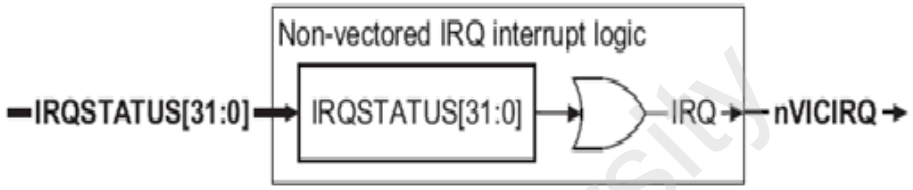


Figure 2.4 : Non-vectored IRQ interrupt logic[25]

Vectored interrupt block

There are 16 vectored interrupt blocks. The vectored interrupt blocks receive the IRQ interrupt requests and set VECTIRQX if the following are true:

• the selected interrupt is active

• the selected interrupt is currently the highest requesting interrupt.

Each vectored interrupt block also provides a VECTADDRX[31:0] output that we can use in the interrupt priority block.

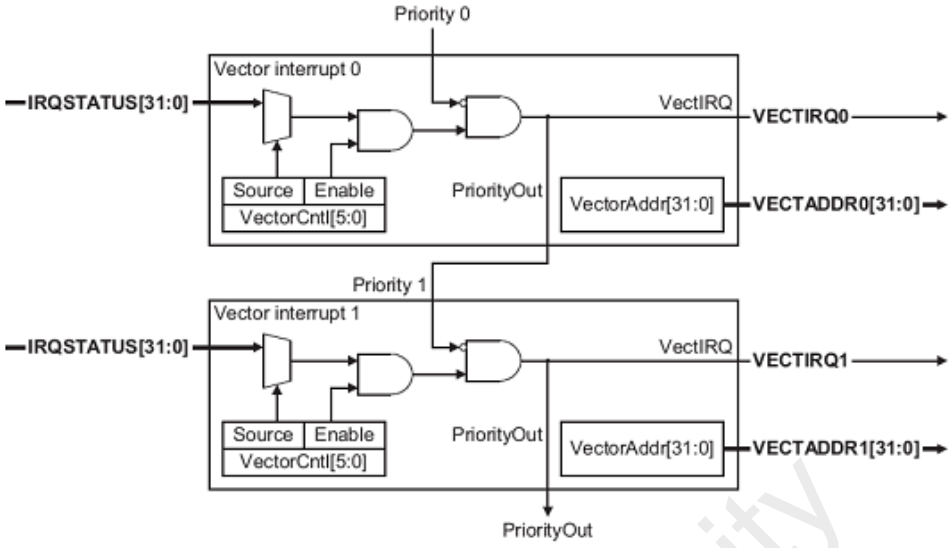


Figure 2.5:Vectored interrupt block[25]

Interrupt priority logic

The interrupt priority block prioritizes the following requests:

• non-vectored interrupt requests

• vectored interrupt requests

• external interrupt requests.

The highest priority request generates an IRQ interrupt if the interrupt is not currently being serviced

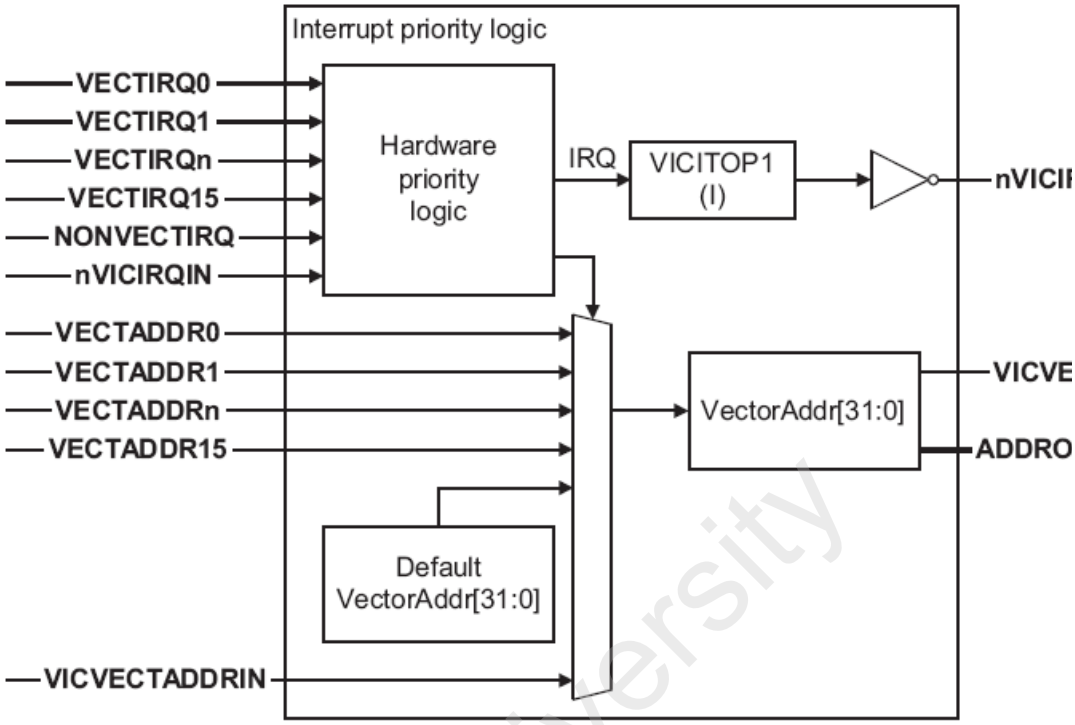


Figure 2.6:Interrupt priority logic[25]

Vectored interrupts

A vectored interrupt is only generated if the following are true:

• we enable it in the interrupt enable register, VICIntEnable

• we enable it in the relevant vector control register, VICVectCntl[0-15].

This prevents multiple interrupts being generated from a single interrupt request if the controller is incorrectly programmed.

Software interrupts

The software can control the source interrupt lines to generate software interrupts .These interrupts are generated before interrupt masking, in the same way as external source interrupts. You clear software interrupts by writing to the Software Interrupt Clear Register, VICSoftIntClear. This is normally done at the end of the interrupt service routine.

2.3.4 Operation

The following sections describe the operation of the VIC:

• Vectored interrupt flow sequence

• Simple interrupt flow

Vectored interrupt flow sequence

The following procedure shows the sequence for the vectored interrupt flow:

1. An interrupt occurs.

2. The ARM processor branches to either the IRQ or FIQ interrupt vector.

3. If the interrupt is an IRQ, read the VICVectAddr Register and branch to the interrupt service routine.

4. Stack the workspace so that you can re-enable IRQ interrupts.

5. Enable the IRQ interrupts so that a higher priority can be serviced.

6. Execute the Interrupt Service Routine (ISR).

7. Clear the requesting interrupt in the peripheral, or write to the VICSoftIntClear Register if the request was generated by a software interrupt.

8. Disable the interrupts and restore the workspace.

9. Write to the VICVectAddr Register. This clears the respective interrupt in the internal interrupt priority hardware.

10. Return from the interrupt. This re-enables the interrupts.

Simple interrupt flow

The following procedure describes how to use the interrupt controller without using vectored interrupts or the interrupt priority hardware. For example, you can use it for debugging:

1. An interrupt occurs.

2. Branch to the IRQ or FIQ interrupt vector.

3. Branch to the interrupt handler.

4. Interrogate the VICIRQStatus Register to determine the source that generated the interrupt, and prioritize the interrupts if there are multiple active interrupt sources.This takes a number of instructions to compute.

5. Branch to the correct ISR.

6. Execute the ISR.

7. Clear the interrupt. If a software interrupt generated the request, you must write to the VICSoftIntClear Register.

8. Check the VICIRQStatus Register to ensure that no other interrupt is active. If there is an active request, go to Step 4.

9. Return from the interrupt.

2.3.5 Register descriptions

The following registers are described in this section[23]:

• IRQ Status Register, VICIRQSTATUS

• FIQ Status Register, VICFIQSTATUS

• Raw Interrupt Status Register, VICRAWINTR

• Interrupt Select Register, VICINTSELECT

• Interrupt Enable Register, VICINTENABLE

• Interrupt Enable Clear Register, VICINTENCLEAR

• Software Interrupt Register, VICSOFTINT

• Software Interrupt Clear Register, VICSOFTINTCLEAR

• Protection Enable Register, VICPROTECTION

• Vector Address Register, VICADDRESS

• Software Priority Mask Register, VICSWPRIORITYMASK

• Vector Address Registers, VICVECTADDR[0-31]

• Vector Priority Registers, VICVECTPRIORITY[0-31]

IRQ Status Register, VICIRQSTATUS

The VICIRQSTATUS Register provides the status of interrupts [31:0] after IRQ masking. Because of the use of dual-stage synchronization logic, the VICIRQSTATUS Register takes two clock cycles to update. This register can be accessed with zero wait states .To access the sampled status of the interrupts, use the ISS bit in the VICITCR Register When a system has multiple VICs, and the VICIRQSTATUS Register is used to determine which interrupt source must be served (instead of using the VIC port or reading the VICADDRESS Register), the interrupt handler might have to read the VICIRQSTATUS Register of all the VICs in the system. This is because the

interrupt status from daisy-chained VICs cannot be observed from the VICIRQSTATUS Register for the first VIC connected to the processor.

FIQ Status Register, VICFIQSTATUS

The VICFIQSTATUS Register provides the status of the interrupts after FIQ masking. The VICFIQSTATUS Register is 32 bits wide. There is normally only one FIQ in the system. You can allow more than one interrupt source to generate a FIQ. The FIQ handler can then read this register to determine which FIQ interrupt source is active. Because of the use of dual-stage synchronization logic, the VICFIQSTATUS Register takes two clock cycles to update. This register can be accessed with zero wait states. This register is 32 bits wide to allow the FIQ to be placed on any of the input interrupt lines, but a typical system only contains one FIQ interrupt source. When a system has multiple VICs, and the FIQ source can be located on a daisy-chained VIC, the interrupt handler might have to read the VICFIQSTATUS Register of all the VICs in the system. This is because the interrupt status from daisy-chained VICs cannot be observed from the VICFIQSTATUS Register for the first VIC connected to the processor.

Raw Interrupt Status Register, VICRAWINTR

The VICRAWINTR Register provides the unmasked status of the interrupt sources (either hardware or software). Because of the use of dual-stage synchronization logic, the VICRAWINTR Register takes two clock cycles to update. This register can be accessed with zero wait states.

Interrupt Select Register, VICINTSELECT

The VICINTSELECT Register selects whether the corresponding interrupt source generates an FIQ or IRQ interrupt. This register can be accessed with zero wait state.

Interrupt Enable Register, VICINTENABLE

The VICINTENABLE Register enables the interrupt request lines, by unmasking the interrupt sources for the IRQ interrupt. This register can be accessed with zero wait states.

Interrupt Enable Clear Register, VICINTENCLEAR
The VICINTENCLEAR Register clears bits in the VICINTENABLE Register, and masks out the interrupt sources for the IRQ interrupt. This register can be accessed with zero wait states.

Software Interrupt Register, VICSOFTINT
The VICSOFTINT Register is used to generate software interrupts. This register can be accessed with zero wait states.

Software Interrupt Clear Register, VICSOFTINTCLEAR
The VICSOFTINTCLEAR Register clears bits in the VICSOFTINT Register. This register can be accessed with zero wait states.

Protection Enable Register, VICPROTECTION
The VICPROTECTION Register enables or disables protected register access**,** stopping register accesses when the processor is in User mode. This register can be accessed with zero wait states.

Vector Address Register, VICADDRESS
The VICADDRESS Register contains the Interrupt Service Routine (ISR) address of the currently active interrupt. If no interrupt is currently active, the register holds the ISR address of the last active interrupt. This register can be accessed with zero wait states.

Software Priority Mask Register, VICSWPRIORITYMASK
The VICSWPRIORITYMASK Register contains the mask value for the interrupt priority levels. This register can be accessed with zero wait states.

Vector Address Registers, VICVECTADDR[0-31]
The VICVECTADDR[0-31] Registers contain the ISR vector addresses. These registers can be accessed with one wait state.

Chapter 3 : Problem Statement

IRQs, or non vectored IRQs depending on the priority. A vectored interrupt controller provides software interface to the interrupt system. The VIC enables the OS interrupt handler to quickly dispatch service routines in response to peripheral interrupts. A vectored interrupt controller is a hardware device that receives interrupts form multiple sources, and forward the interrupt requests to the processor.

Generally, we only use a single FIQ source at a time in a system to provide a true low-latency interrupt. This has the benefits that we can execute the interrupt service routine directly without determining the source of the interrupt and also it reduces interrupt latency. One can use the banked registers available for FIQ interrupts more efficiently, because we do not require a context save.

As explained in the Literature Survey, FIQs hold the highest priority above all of the interrupts whether it is vectored IRQ or non vectored. If both of them occur simultaneously than the priority need not be even checked only FIQ interrupt is to be serviced. Well in this case if only IRQ interrupt occurs than only the priority is to be checked and highest priority interrupt should preempt the resources for its service but problem is to check the condition whether FIQ interrupt preempts the resources for its service if there is an occurrence of FIQ when IRQ is being serviced, we have the test cases to check that condition the first condition but not the second condition.

There are some small conditions which one may over look but are of significant importance in long run. There are some condition's which require concern :-

1. Checking whether an IRQ line which is configured and enabled can be re-configured while it is enable.
2. Checking whether an FIQ line which is configured and enabled can be re-configured while it is enable.

Therefore to check whether FIQ pre-empts from IRQ and other conditions we need to design a test case in which these condition will be generated and response will be noted to check the condition is satisfied or not, with a condition that these interrupts will be generated by software itself. The test case validation will be done using NUTS. Now after defining the problem statement we move on to the designing of the test case which require some pre requisites after that we will test the test case for validity.

CHAPTER 4 : Designing and implementation of Test Cases on VIC

Before beginning with the solution for the above stated problem lets have a look at a view of what happens when an interrupt is generated from a hardware and after that a look at the Interrupt Flow Sequence Diagram .

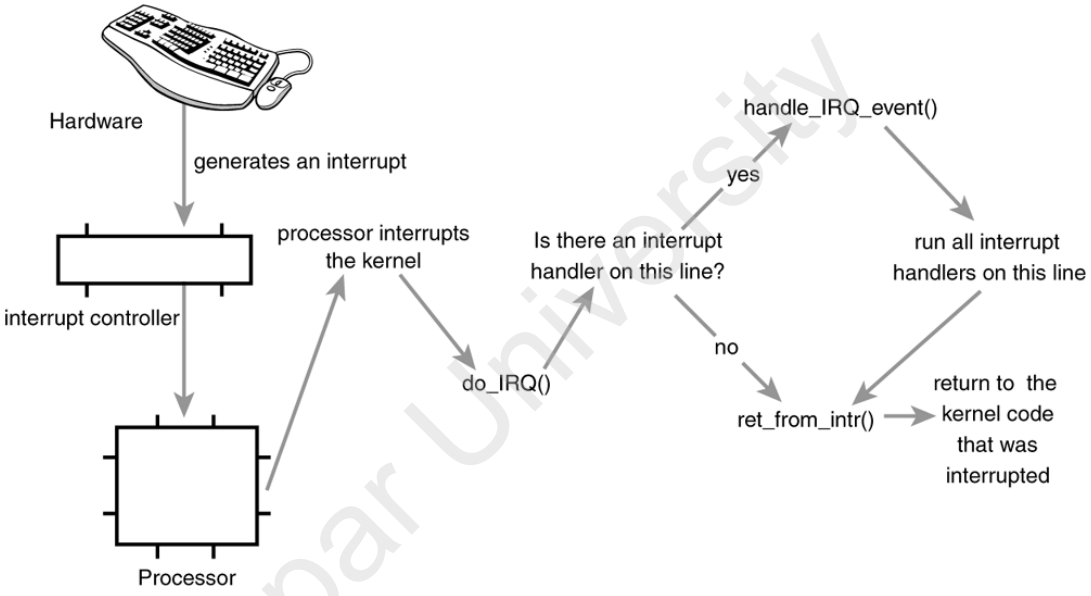


Figure 4.1: Interrupt Flow Sequence

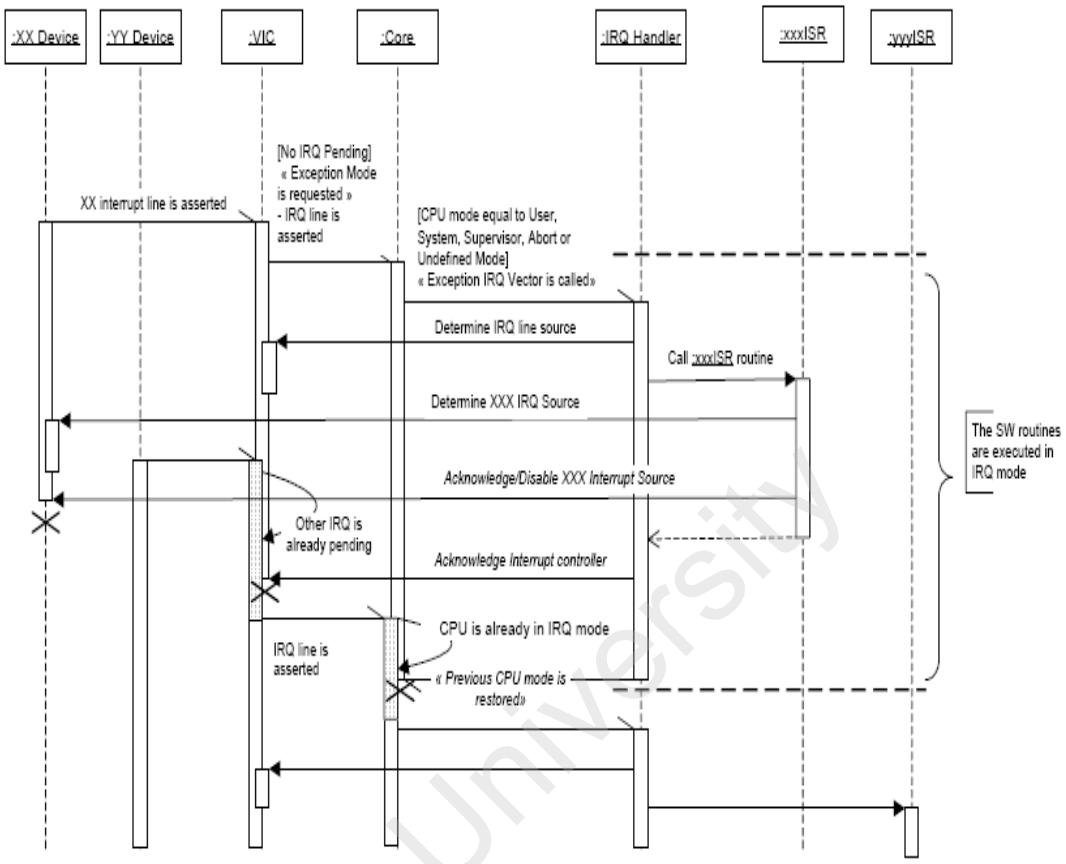


Figure 4.2:State Chart Diagram For Interrupt Flow

IRQ handler is the first routine called when the IRQ has been taken into account by the core. It allows to identify the pending interrupts and to call the relevant ISRs (In most case each interrupt line is associated with a ISR routine).

The ISRs are executed in the context of the IRQ handler (IRQ mode). Before to leave this mode and to acknowledge the interrupt controller, the interrupt source must be acknowledged (masked or disabled) to avoid to generate a new IRQ request with the same pending interrupt source. This acknowledgement normally occurs when the interrupt service routine accesses the device causing the interrupt.

The designing of the test case consists of :-

i. Designing of IRQ interrupt handler.

ii. Designing of FIQ interrupt handler.

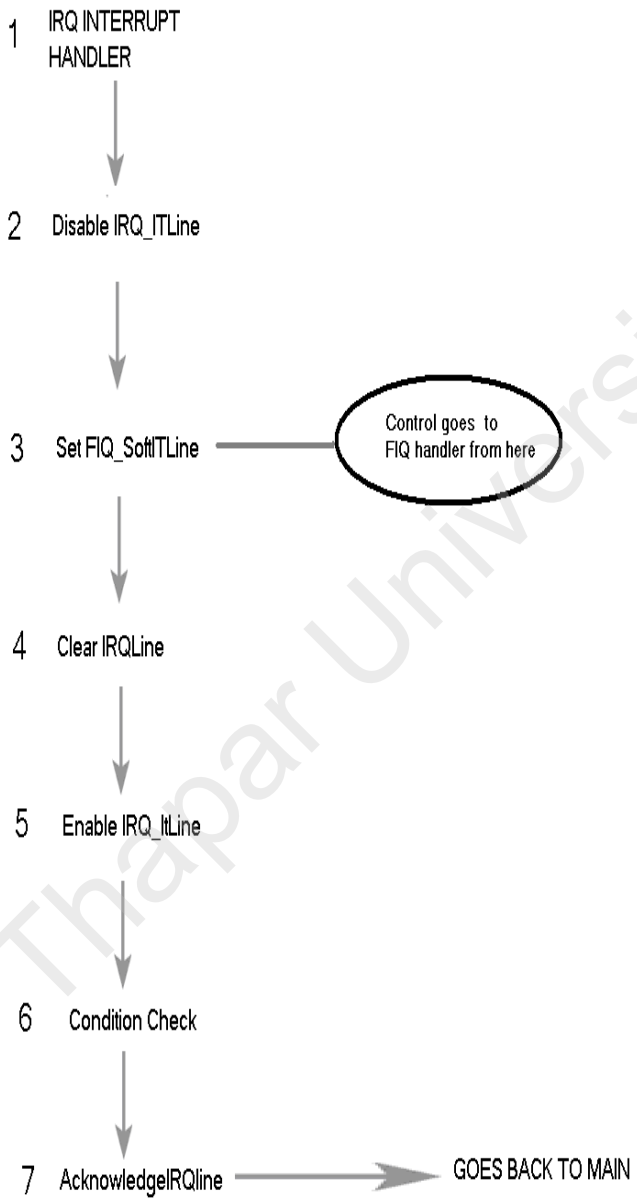
iii. Preemption of IRQ by FIQ.

iv. IRQ line which is configured and enabled can be re-configured while it is enabled.

v. FIQ line which is configured and enabled can be re-configured while it is enabled.

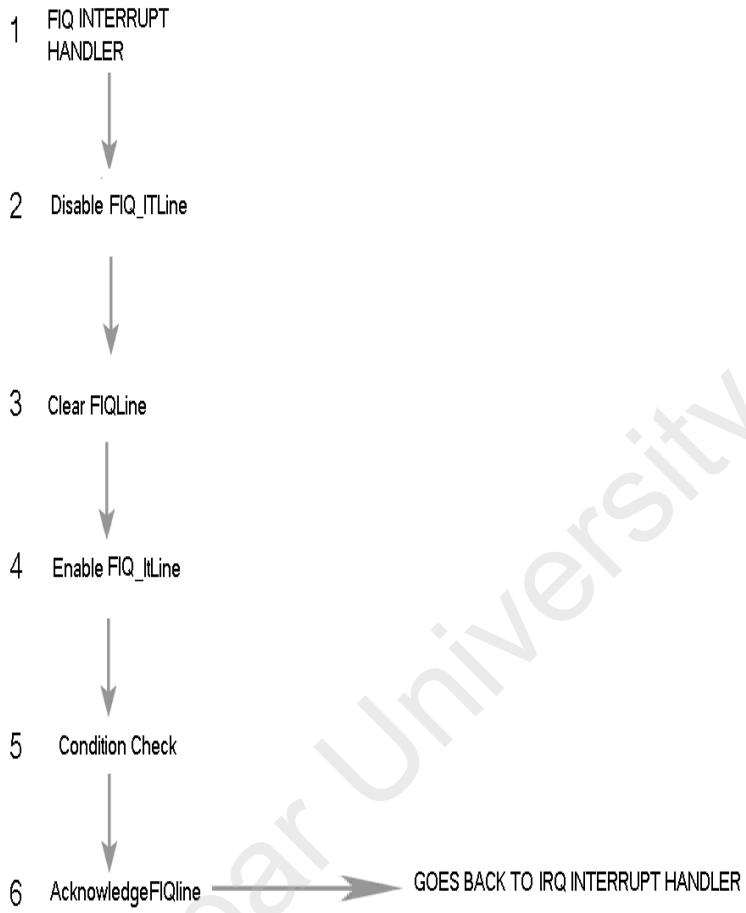
To begin with the designing of the test case we start of with designing of IRQ handler. We need to design a different interrupt handler for each of the test cases to be developed, but that interrupt handler is locally declared .Global declaration is done when the handler is assigned to a hardware device like if a condition arises where WATCHDOG TIMER needs the resources than that mean an FIQ is generated now a particular interrupt handler is binded to watchdog timer , i.e that interrupt handler will be called whenever a interrupt is generated by watchdog timer. After that we will design FIQ handler and then we will develop the first part of our test case that is checking whether FIQ pre-empts IRQ or not .

4.1 Designing of IRQ interrupt handler.



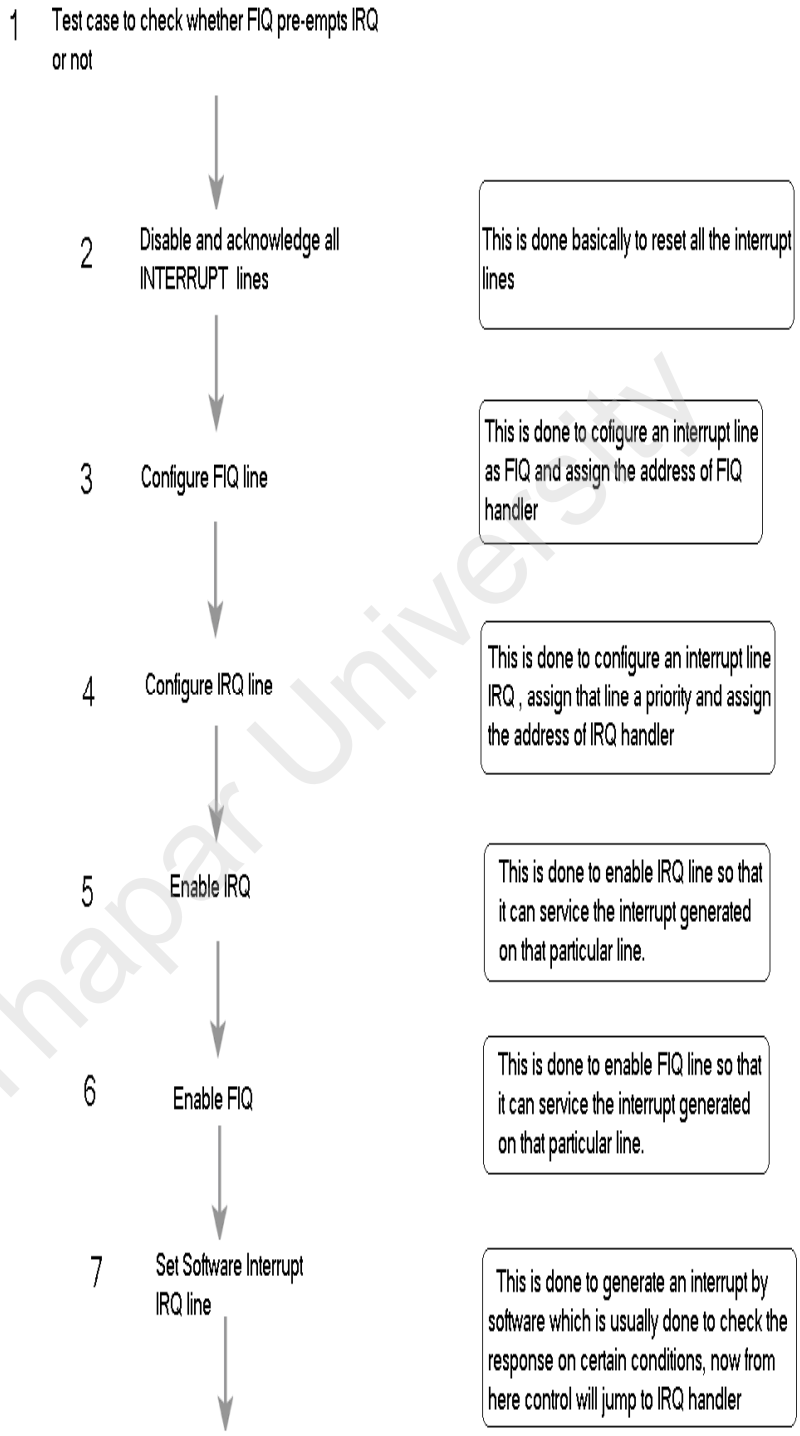
In IRQ interrupt handler first of all we disable that interrupt line from where that interrupt is generated so that another interrupt is not generated at the same line after disabling the IRQ line we will set the FIQ line, enable FIQ line to see whether the control goes to FIQ interrupt handler or not. After that irrespective of what happens at step 3 clear the IRQ line so that in the next step we can enable the IRQ line again so that it is ready to accept another INTERRUPT on the same line after that we put a condition check which determines whether FIQ was able to preempt IRQ or not if not than an error message will be displayed and lastly the control will go back to main after acknowledging the IRQ line.

4.2 Designing of FIQ interrupt handler.



In FIQ handler the steps are similar to that of IRQ handler, initially we disable the FIQ interrupt line so that if any other interrupt is generated on that line it is not serviced. After servicing the FIQ interrupt FIQ line is cleared so that it can be enabled and be available for another interrupt generation on the same line . Now we have a condition check to determine whether IRQ was per-empted on not if yes than the value generated is used by IRQ handler and lastly after acknowledgement of FIQ line control goes back to IRQ handler.

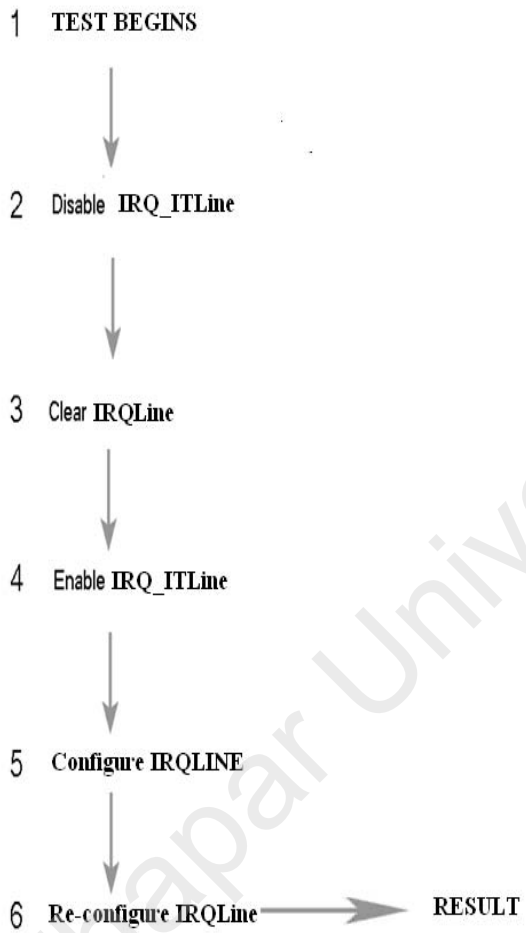
4.3 To check whether IRQ is pre-empted by FIQ or not



This test case designed checks whether FIQ pre-empts IRQ or not. To begin with as the control jumps from main to the test case initially all the interrupt lines are disabled than we configure the IRQ line and FIQ line. By configuring I mean to say the line is

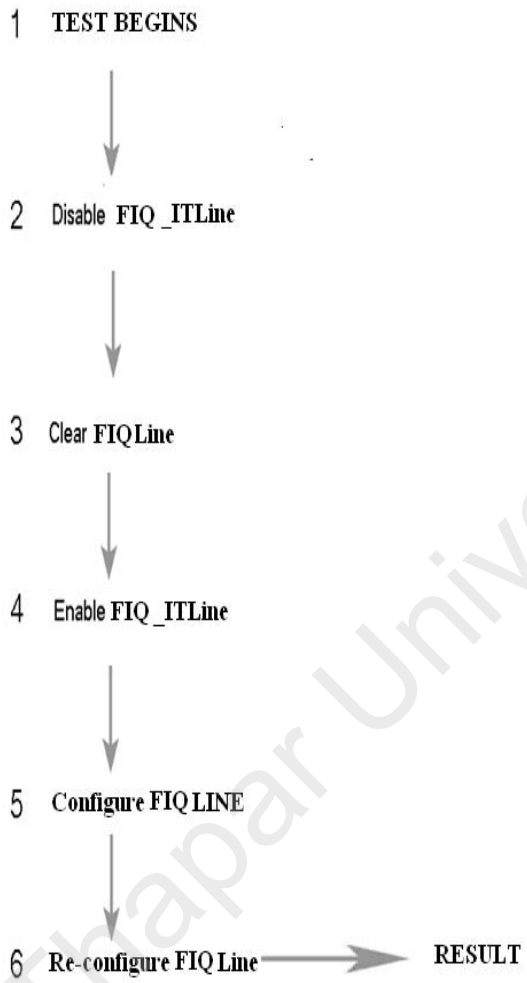
assigned some priority and the interrupt handler address is binded to it which tells the controller where to go if an interrupt is generated on that particular line. After that we enable both the lines so that if can interrupt is generated it can be serviced. Since we generate the interrupt through software therefore we set the IRQ line, as we set that line the control jumps to the IRQ handler and rest is handled by the IRQ handler.

4.4 Checking functionality of VIC_configIRQline API, when Line is reconfigured



This test case checks whether a line configured as IRQ line can be re-configure or not. To begin with disable IRQ line and than clear IRQ line than we enable it and configure it by assigning interrupt handler address to it and than we reconfigure the same line to see that the line configured can not be re-configured until and unless it is disabled and cleared.

4.5 Checking functionality of VIC_configFIQline API, when Line is reconfigured



This test case checks whether a line configured as FQ line can be re-configure or not. To begin with disable FIQ line and than clear FIQ line than we enable it and configure it by assigning interrupt handler address to it and than we reconfigure the same line to see that the line configured can not be re-configured until and unless it is disabled and cleared.

CHAPTER : 5 : Testing tools & Testing of test case

SYSTEM REQUISITES

5.1 RATIONAL CLEARCASE-A tool for configuration management

Rational ClearCase is a software tool for revision control (e.g. configuration management, SCM) of source code and other software development assets. It is developed by the Rational Software division of IBM. Clear Case forms the base of version control for many large and medium sized businesses and can handle projects with hundreds or thousands of developers.

It provides a central repository for all the files along with their different versions so that at any point of time if any required version of any file can be retrieved easily without dependency on anybody. It preserves the earlier version of files created so that if required later the previous version of the modified version one can retrieve the file from where it started. Multisite feature provided by Clear Case allows users at geographically distributed locations to carry out their work on the same piece of code. Branching feature provided by Clear Case allows different users to carry out their work simultaneously on the same piece of code without interfering each other's work.

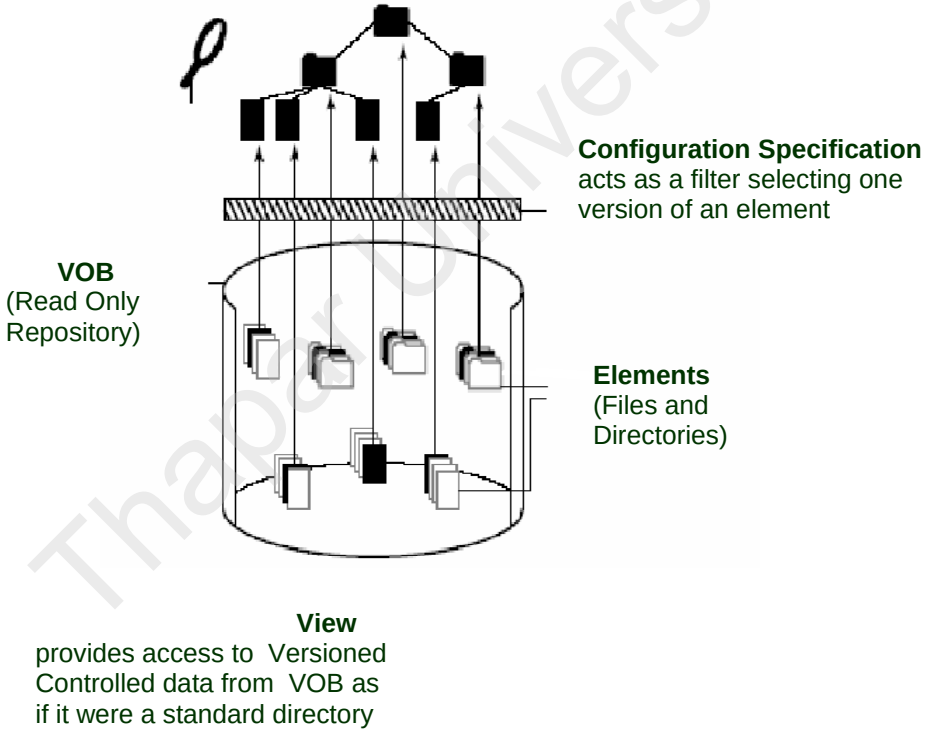
SOME terms used in clear case --

- VOB :-Versioned Object Base. In Clear Case, files and directories, are stored in a read-only repository called a versioned object base or VOB.
- Element:-All files and directories stored in a VOB are called Element
- Version:-A version is a particular revision of a file or directory element.
- View:- View is a virtual workspace for an individual developer or closely coordinated group which selects versions of VOB directories and files to display.

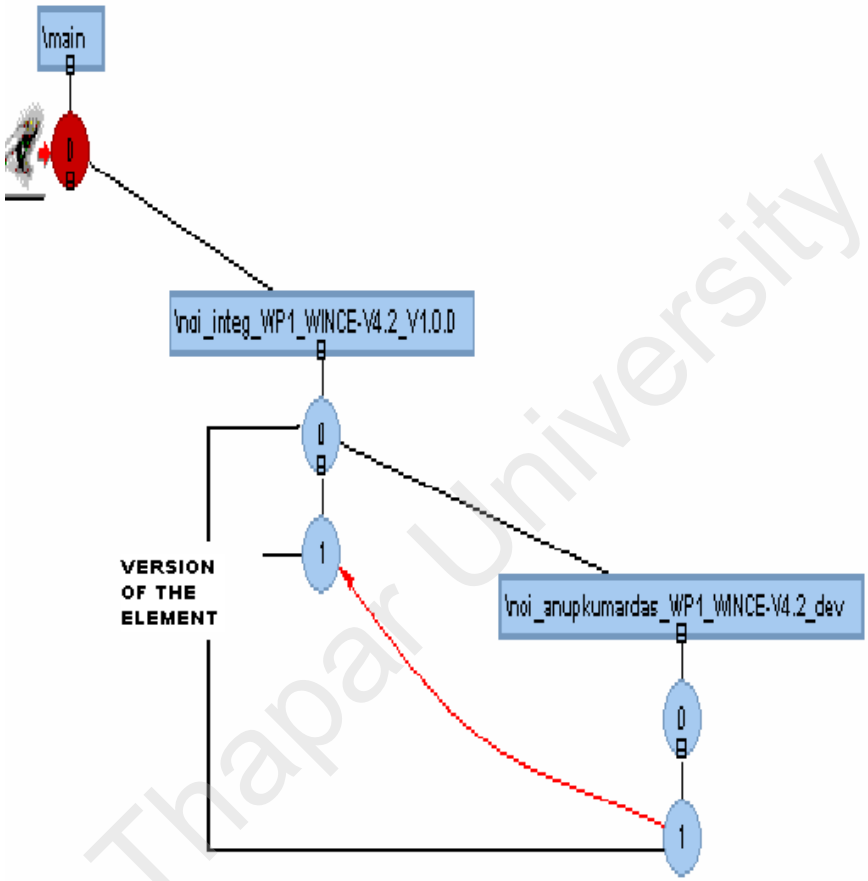
- Configuration Specification: A set of rules which determines which version of an element will be selected in a particular view.

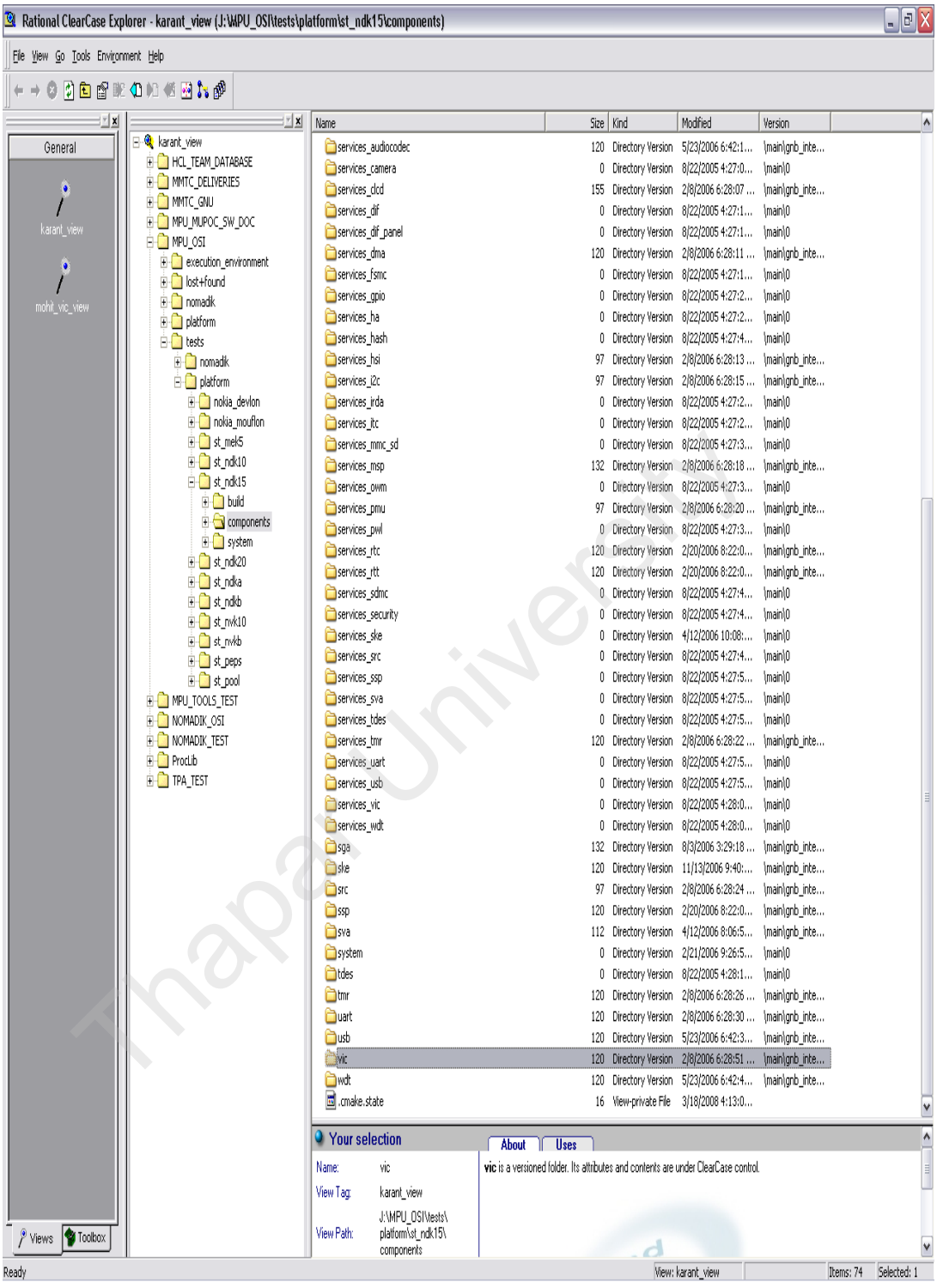
- Version Tree: A hierarchical representation of an element in which all versions are logically organized. Each 'version tree' has a main branch. A user can create any number of sub-branches.

BASIC VIEW OF HOW CLEARCASE REPRESENTS THE FILE s



VERSION TREE REPRESENTATION IN CLEARCASE




Rational ClearCase Explorer - karant_view (J:\MPU_OSI\tests\platform\st_ndk15\components)
File View Go Tools Environment Help
General
karant_view
mohit_vic_view
Views
Toolbox
karant_view
HCL_TEAM_DATABASE
MMTC_DELIVERIES
MMTC_GNU
MPU_MUPOC_SW_DOC
MPU_OSI
execution_environment
lost+found
nomadik
platform
tests
nomadik
platform
nokia_devlon
nokia_mouflon
st_mek5
st_ndk10
st_ndk15
build
components
system
st_ndk20
st_ndka
st_ndkb
st_nvk10
st_nvkb
st_peps
st_pool
MPU_TOOLS_TEST
NOMADIK_OSI
NOMADIK_TEST
ProcLib
TPA_TEST
Name Size Kind Modified Version
services_audiocodec 120 Directory Version 5/23/2006 6:42:1... \main\gnb_inte...
services_camera 0 Directory Version 8/22/2005 4:27:0... \main\0
services_clcd 155 Directory Version 2/8/2006 6:28:07 ... \main\gnb_inte...
services_dif 0 Directory Version 8/22/2005 4:27:1... \main\0
services_dif_panel 0 Directory Version 8/22/2005 4:27:1... \main\0
services_dma 120 Directory Version 2/8/2006 6:28:11 ... \main\gnb_inte...
services_fsmc 0 Directory Version 8/22/2005 4:27:1... \main\0
services_gpio 0 Directory Version 8/22/2005 4:27:2... \main\0
services_ha 0 Directory Version 8/22/2005 4:27:2... \main\0
services_hash 0 Directory Version 8/22/2005 4:27:4... \main\0
services_hsi 97 Directory Version 2/8/2006 6:28:13 ... \main\gnb_inte...
services_i2c 97 Directory Version 2/8/2006 6:28:15 ... \main\gnb_inte...
services_irda 0 Directory Version 8/22/2005 4:27:2... \main\0
services_itc 0 Directory Version 8/22/2005 4:27:2... \main\0
services_mmc_sd 0 Directory Version 8/22/2005 4:27:3... \main\0
services_msp 132 Directory Version 2/8/2006 6:28:18 ... \main\gnb_inte...
services_owm 0 Directory Version 8/22/2005 4:27:3... \main\0
services_pmu 97 Directory Version 2/8/2006 6:28:20 ... \main\gnb_inte...
services_pwl 0 Directory Version 8/22/2005 4:27:3... \main\0
services_rtc 120 Directory Version 2/20/2006 8:22:0... \main\gnb_inte...
services_rtt 120 Directory Version 2/20/2006 8:22:0... \main\gnb_inte...
services_sdmc 0 Directory Version 8/22/2005 4:27:4... \main\0
services_security 0 Directory Version 8/22/2005 4:27:4... \main\0
services_ske 0 Directory Version 4/12/2006 10:08:... \main\0
services_src 0 Directory Version 8/22/2005 4:27:4... \main\0
services_ssp 0 Directory Version 8/22/2005 4:27:5... \main\0
services_sva 0 Directory Version 8/22/2005 4:27:5... \main\0
services_tdes 0 Directory Version 8/22/2005 4:27:5... \main\0
services_tmr 120 Directory Version 2/8/2006 6:28:22 ... \main\gnb_inte...
services_uart 0 Directory Version 8/22/2005 4:27:5... \main\0
services_usb 0 Directory Version 8/22/2005 4:27:5... \main\0
services_vic 0 Directory Version 8/22/2005 4:28:0... \main\0
services_wdt 0 Directory Version 8/22/2005 4:28:0... \main\0
sga 132 Directory Version 8/3/2006 3:29:18 ... \main\gnb_inte...
ske 120 Directory Version 11/13/2006 9:40:... \main\gnb_inte...
src 97 Directory Version 2/8/2006 6:28:24 ... \main\gnb_inte...
ssp 120 Directory Version 2/20/2006 8:22:0... \main\gnb_inte...
sva 112 Directory Version 4/12/2006 8:06:5... \main\gnb_inte...
system 0 Directory Version 2/21/2006 9:26:5... \main\0
tdes 0 Directory Version 8/22/2005 4:28:1... \main\0
tmr 120 Directory Version 2/8/2006 6:28:26 ... \main\gnb_inte...
uart 120 Directory Version 2/8/2006 6:28:30 ... \main\gnb_inte...
usb 120 Directory Version 5/23/2006 6:42:3... \main\gnb_inte...
vic 120 Directory Version 2/8/2006 6:28:51 ... \main\gnb_inte...
wdt 120 Directory Version 5/23/2006 6:42:4... \main\gnb_inte...
.cmake.state 16 View-private File 3/18/2008 4:13:0...
Your selection
About Uses
Name: vic
View Tag: karant_view
View Path: J:\MPU_OSI\tests\platform\st_ndk15\components
vic is a versioned folder. Its attributes and contents are under ClearCase control.
Ready
View: karant_view
Items: 74
Selected: 1

5.2 TRACE 32

The TRACE32 In-Circuit Debuggers are highly cost effective tools for debugging on assembler or HLL level. The ICD-Debugger are mainly used as stand-alone debugger on a PC or workstation. TRACE32 can directly load the output of all standard compilers for C, C++, JAVA, Pascal, Modula2, PEARL and ADA from most compiler vendors. Program display and debugging can be done in assembler, high-level or in a mixture of both. It is possible to construct both assembler and high-level windows on the screen simultaneously. All variable types specific to the high level language can be displayed and modified. Addresses can be absolute, relative or line number based.

The TRACE32 development tool can be connected with a standard USB cable to any free plug on the PC. If a peripheral (e.g. keyboard) connected to the PC provides an USB hub, also these plugs can be used for connection. The USB is hot-pluggable , that means the TRACE32 development tool can be connected even if the power of the PC and/or the TRACE32 development tool is on.

5.3 METROWORKS

The CodeWarrior IDE™ provides a set of tools for developing computer software. Using the IDE, you can develop a program, plug-in, library, or other executable code to run on a wide variety of computer systems using different programming languages. You can accomplish all your code-development tasks using the graphical user interface of the IDE.

The CodeWarrior IDE includes compilers, linkers, a source-code browser, a debugger, an editor, and a rapid application development tool set. You can use the IDE to edit, navigate, examine, compile, and link code throughout your software development process. You can also configure options for code generation, project navigation, and other operations.

4.4 NUTS- NOMADIK UNIFIED TESTING SYSTEM

NUTS (Nomadik Unified Test System) provide tests framework to validate embedded code for the nomadic chip. Using NUTS with its command line tool provide scripting facilities to automate execution into NUTS. Using NUTS we can automate the test cases and run all the test cases without user intervention**.** NUTS is used to run the Test cases.

In NUTS-

A Test Case is a definition of a test to be executed.

A Test Plan is a set of Test Cases where each Test Case is identified by a unique id within the Test Plan.

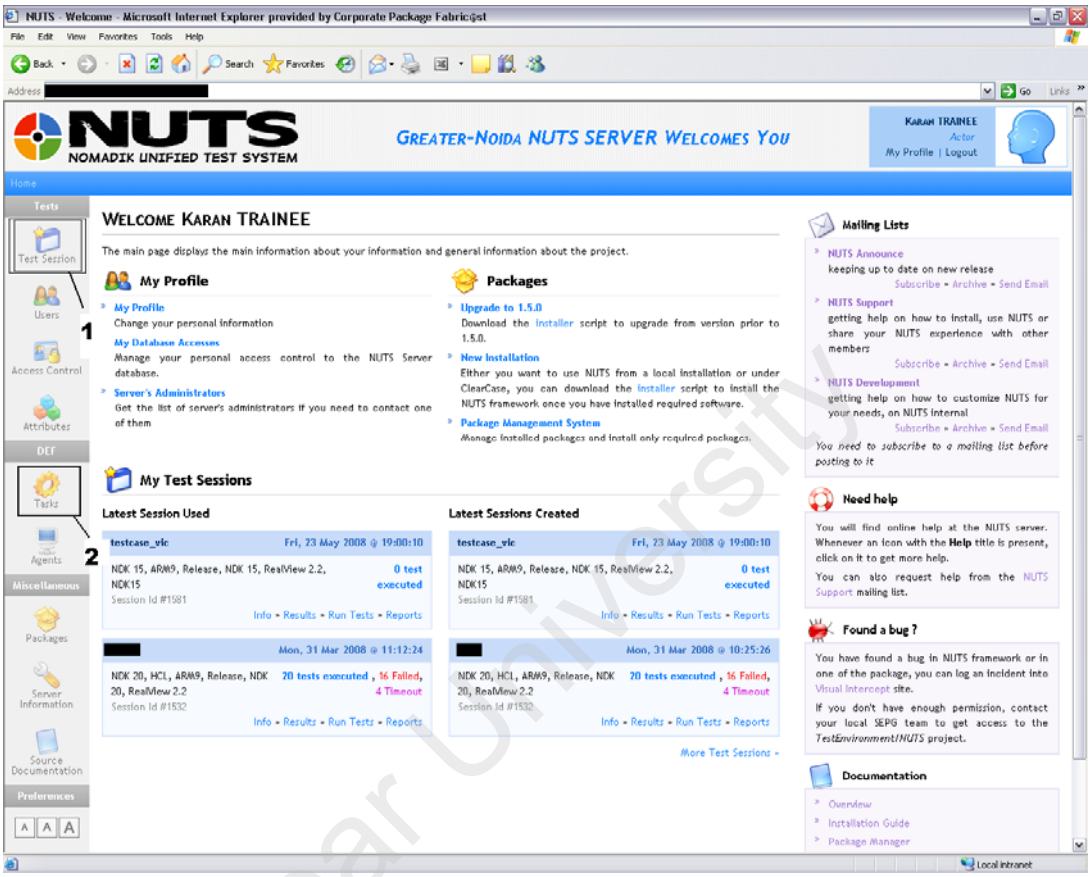
A Test Class Runner is a class implementing a test execution workflow.

A Test Case can be executed by one and only one Test Class Runner. A Test Class Runner can execute one or many Test Cases.

A Test Session is a collection of information used to execute tests: it contains a Test Plan, a ROM image (compiled with tests to execute) and whenever a test is executed, the result of the tests is stored within the Test Session.

This is the homepage of NUTS which shows all the main information about the project carried out for a particular LOGIN name.

WORKING WITH NUTS



1.Open the url.

2.Enter username and password(before that please ensure you have the admin rights for your system

3.Click on access control icon on the left side of the nuts homepage screen

4. `<param name="Database.UserName">*</param>`
<param name="Database.Password">*</param>

Check your username and password appearing on the screen to be there where * appears in the above two documents.

If username and password doesn't appear there make changes in the conf. file of nuts which lies at the following given path
C:\NUTS\conf
(Conf file)

5.Now goto homepage and click test session to start a test session

**to begin with a new test session or to create a new test session click on the *(star) that appears on the right hand side top of the screen

6.starting with new session we need to fill up some entries.

After Filling up the entries

Click on next

Now you have filled in the details of all the attributes required for the test.

The page will appear somewhat like this after filling up the details.

7. No control image is to be loaded therefore click on save

8. After defining the attributes we need to do the building and compilation of the tests

9. Click on task on the lefthand side of the screen which appeared after clicking on save in 7th step.

10. We need to consider only on the following three attributes

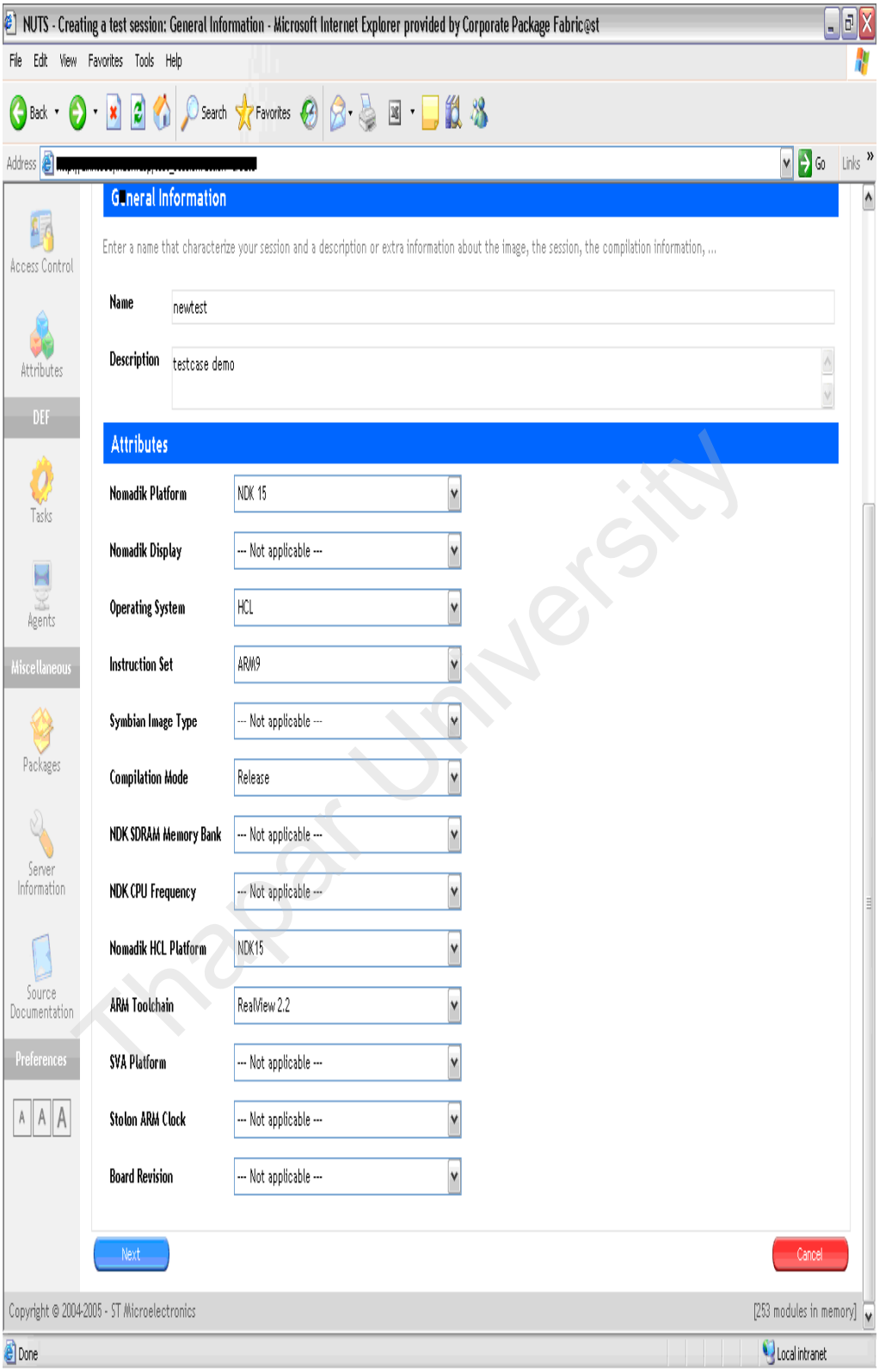
Build HCL using MakeEnv
Generate HCL Tests main C files
Generate an HCL test plan including required component(s)

Only 1st & 3rd will be used
1st click on GetTestPlan but before that do ensure you have the following three files include in your makeenv folder where the config file for that particular component is placed.(THIS IS PLACED IN THE VOB)

Tests_list.txt

Tests_list_dev.txt

Tests_list_valid.txt



Note-these three files are associated with the components these files content are not common for all the components.

Now fill in the getplan entries

1. session id-
(if not known , click on test session and there appears a no. before the name of the test that is the session id)

2. merge plan-true

3. platform –st_ndk15 or st_ndk20

4. Component-name of the component

*if you want to specify name of two or more components then specify them with blank space between their names.e.g VIC WDT

5. mode-class

6. prefix –validation

7. timeout-specify if known(otherwise default is enough)

8. RepositoryType-given

9. RepositoryPath-name of the view
(from this view all of the files for that component will be picked)

10.click on local execution in ACTION part

After this a window will pop up,click on open option in that window. After that a command prompt window will pop up showing the execution. When it stops again click on TASKS on the left side of the page to click on getcompile url on the page that appears.

This usage of NUTS is basically automation of Nomadik because earlier we had pearl script written for running the test cases ,in which we need to write the pearl script for running of the test cases for each component , now we need not reset the board everytime we switch over to the other test cases because NUTS does that on its own. Using NUTS we can test more than one component test cases together us.

Now after defining the tools required for designing and testing we move on to the testing of the test cases .The following shows the results of the test case developed.

TEST CASE 1.1

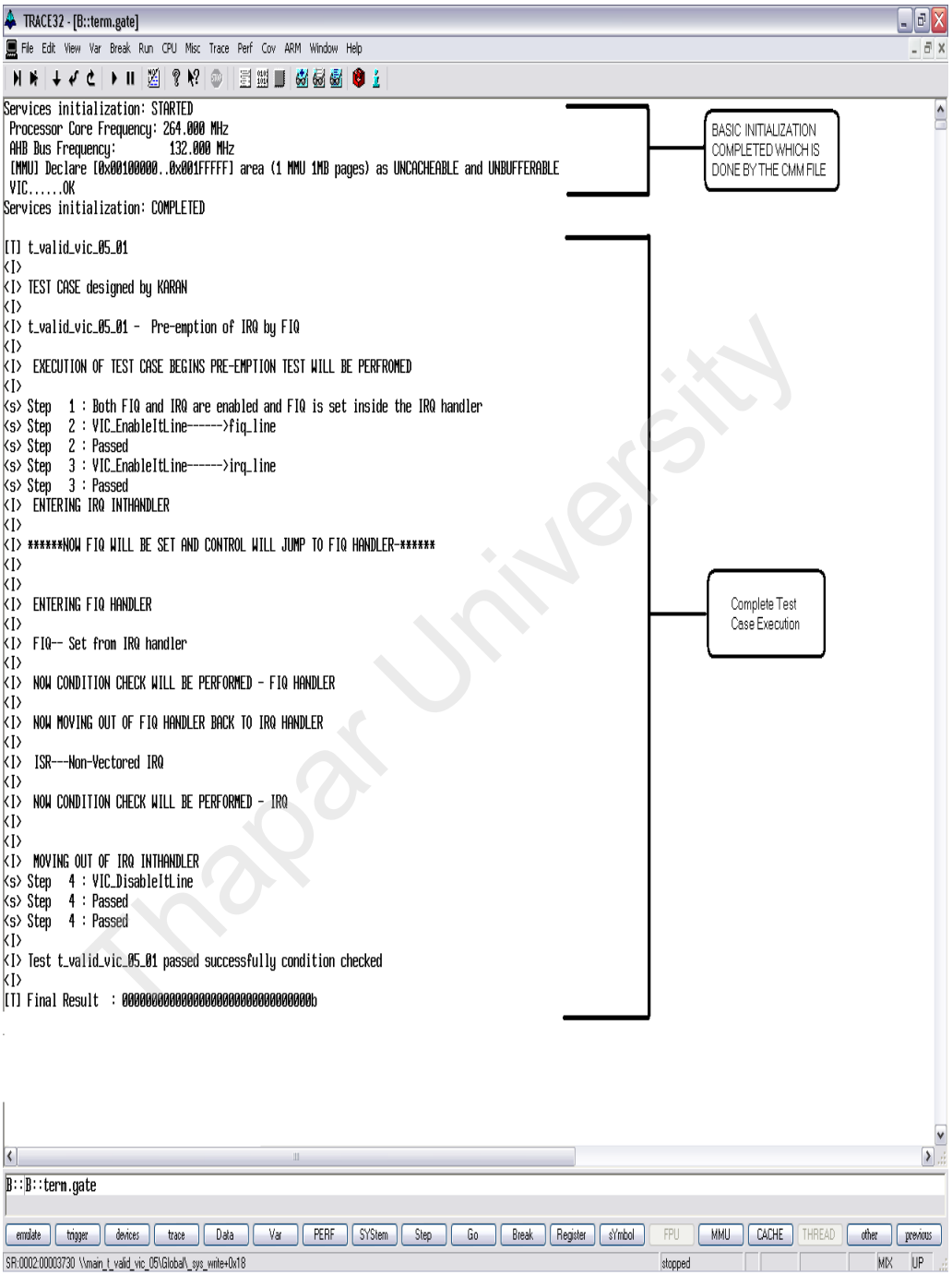


Figure : 5.1

The Figure 5.1 shows the successful running of the test case 1.1 developed to check whether the IRQ can be pre empted from IRQ or not & the result shows that it does pre-empts.

TEST CASE 1.2

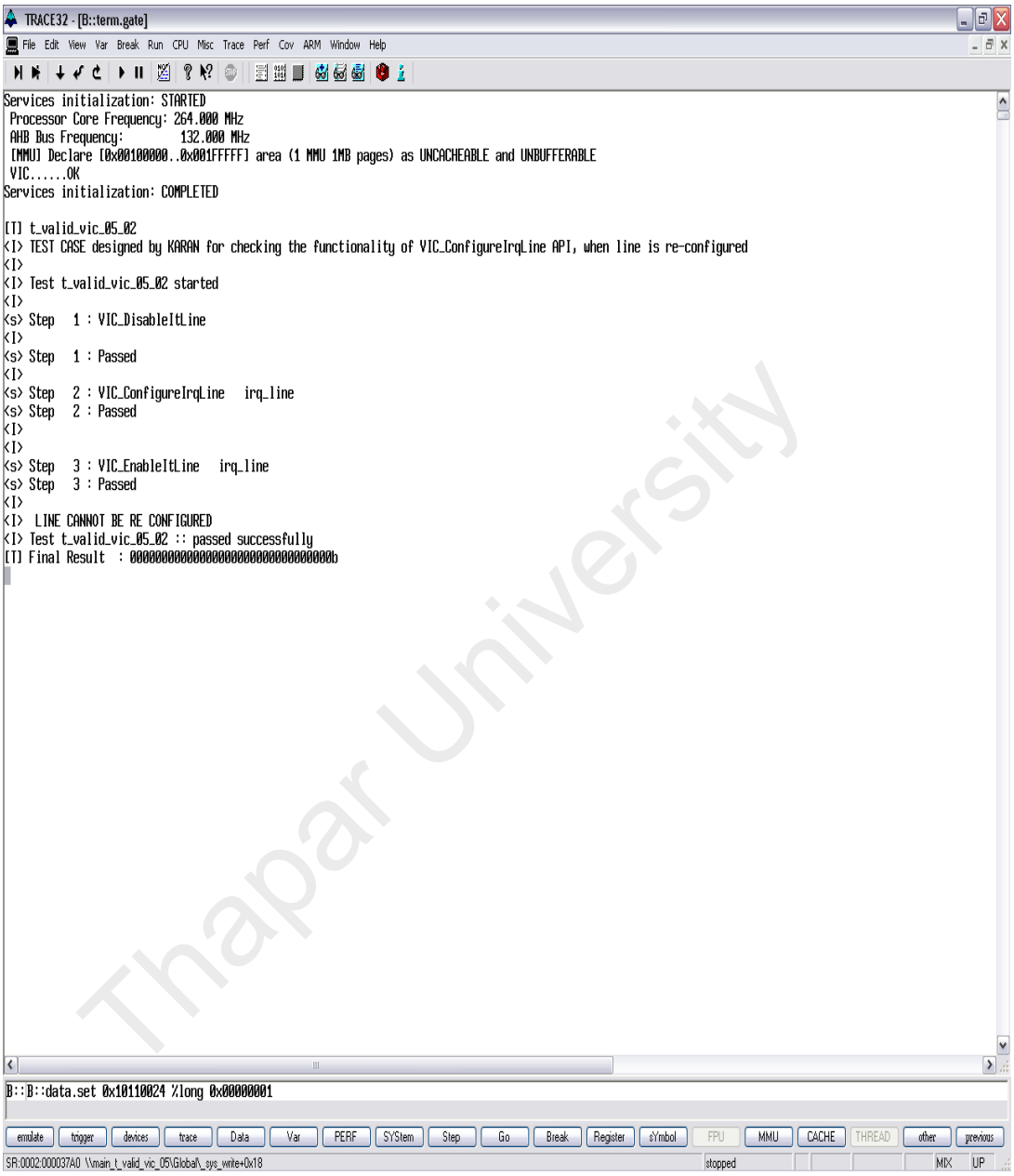


Figure 5.2

The figure 5.2 shows the successful running of test case 1.2 i.e to check whether a line configured as IRQ can reconfigured or not and the result shows that it can't be re-configured.

TEST CASE 1.3

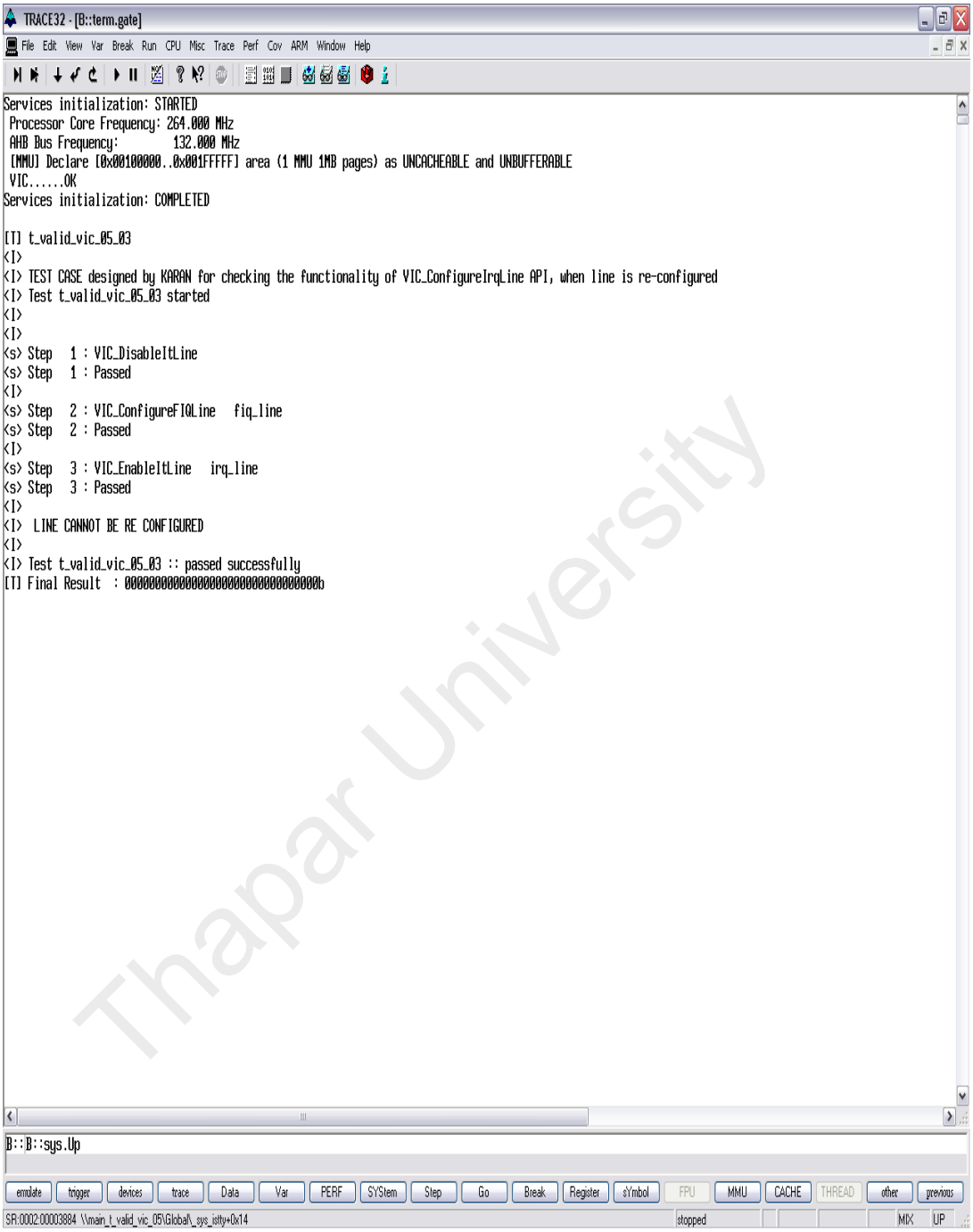


Figure 5.3

The figure 5.3 shows the successful running of the test case 1.3 i.e test case for Checking functionality of VIC_configFIQline API, when Line is reconfigured and it shows that line configured as FIQ cannot be reconfigured..

Now after defining the designing of the test cases , the tools required for testing and development we move on to the next section in which this thesis is concluded.

CHAPTER 6 : Conclusion & Future Work

In this study we have two clear examples of how CRM is done. To begin with CDON.com it use various techniques to form a segment of Customers which can be targeted and products can be sold , where as in the second case to achieve CRM in various forms the test case developed will help in a way i.e semiconductor company can embed better technology for mobile phones which can be used by mobile manufacturer for providing better services to the end consumer .

Often driven by the need to improve customer satisfaction and retention, CRM systems can aid in understanding a customer or segment to focus sales and marketing activities. We will see more of an appreciation that profitability is a key variable in determining cross-sell promotions, product pricing and packaging based on historical as well as future anticipated consumer information. Lifetime value will be better understood to allow for organizations to think about potentially good prospects and the overall return on the relationship that is developed over time. CRM systems will be blended with operational and back- office systems to provide a seamless, real-time data environment. CRM will not only be about servicing the customer better, but also servicing the customer in the best interests of the customer as well as the business itself.

The development of a test case has made the implementation of various function calls for implementation of new technology in mobile much more easier. This development will be beneficial for the mobile manufacturer as well as the end consumer as they will have better technology being implemented more efficiently. Using this test case various peripherals attached to it can be tested for various conditions thus there by offering a platform where various conditions for a particular occurrence of an event can be tested.

The mobile sector in INDIA and in the WORLD is continuously improving its efficiency with the use of new advancements and development in the field of technology. New technology which are developing with time play a great role in

advancement of mobile system. With the awareness spreading at lightning speed rational buyers and their customers have a sense of well being and quality of life as they have long term relationship with the service provider .

While CRM may already seem to be an old and jaded term, there is a bright future ahead that will bring new ways for small and mid-sized organizations to communicate, operate and strategize to manage their personnel, customers and prospects.

In this thesis study of CRM is done which includes study regarding the mobile technology for CRM on the basis of the test cases developed , for some different technology test cases can be developed for same component VIC , but different setup in mind example test case to be developed if there are two or more than two different VIC on the same board than how the co-ordination will be achieved .The above work can be used to do the further work on CRM and its relationship with various industries and how various industries are dependent on each other which on turn forms a chain of CRM .

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