A conceptual data design for an installed base and configuration management for the Philips Healthcare IT products

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TECHNICAL UNIVERSITY EINDHOVEN
Department of Mathematics & Computer Science and
Department of Technology Management

A Conceptual Data Design for an Installed Base and Configuration Management for the Philips Healthcare IT Products*

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Mr. Gerard Haex - Director
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Eindhoven, May 2006.

TECHNICAL UNIVERSITY EINDHOVEN
Department of Mathematics & Computer Science and
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Dedicated to
my mother Sampoornam,
my husband Vijay
and our children
Priya and Ajay
for their love, affection and support.

TECHNICAL UNIVERSITY EINDHOVEN
Department of Mathematics & Computer Science and
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Preface

This thesis would not have existed but for the fact that I was unable to find a new job when I lost my old one during a reorganization in Assembleon Netherlands B.V., (previously Philips Electronic Manufacturing Division), Eindhoven. At the end of 2003, new jobs were scarce, the job market was dismal, and I told myself that if I didn't find a job before January 2004, I would enroll myself at the Technical University Eindhoven. And so, with ten years of work experience under my belt, I signed up for my second masters in Business Information Systems at the Technical University Eindhoven.

For my bachelors degree (in Engineering), I studied Instrumentation and Control. My first masters program was in Business Administration. I opted for my second masters in Business Information systems, which is a combination of technical studies in Information Systems and Business studies related to IT. The course started with great enthusiasm and very soon realized that the academic approach in The Netherlands is vastly different from India, where I did my Bachelors and Masters. The two years were one long struggle, trying a completely different education system and wrapping up five courses in a matter of 9 or 10 weeks (including the electives).

Looking back now, I can proudly say that I have learnt more, not only from an educational point of view but also on the personal front. I immensely enjoyed the method of teaching at the Technical University, and would like to thank the teachers from whom I have learnt in the field of Business Information Systems. And now, I am looking forward to applying them in real life.

Thanks to Mr. Gopal Kamath – Program Director –Philips Semiconductor, who laid the run way, facilitated me to take-off my Masters at the Technical University, Eindhoven and his wife Mrs. Sangeetha Kamath, who supported me during my studies. Thank to Prof.Dr.ir.G.J.P.M Houben, Director of Business Information System, for providing this wonderful opportunity. Finally my thanks go to Mr. Andre Biase – Director from Philips Medical Systems who helped me to find my master thesis subject in the Customer Support field, in which I had around 6 years of experience.

Er. Vadivu Vijayaraghavan, Eindhoven, May 2006.

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Acknowledgements

The realization of this project was possible, due to the guidance and support of various people, without their care and consideration, this master thesis research project would likely not have matured. I would like to deeply thank various people who, during the several months in which this endeavor lasted, provided me with useful and helpful assistance.

First of all I would like to thank Mr. Gerard Haex and Mr. Pieter Both, supervisors from Philips Medical Systems for giving me the opportunity to undergo this research project thesis. I am especially grateful to Mr. Pieter Both for fine tuning to the project's subject (Installed Base and Configuration Management) and I am honored to have him as my supervisor. Thank you for all your kind help and sharing your knowledge.

Secondly, I would like to acknowledge my supervisor from the Technical University of Eindhoven, Dr. ir. Henk Jan Pels. Many thanks for your suggestions and directions in interpreting the 'Conceptual Data Design'. I also thank Dr. A.T.M. Aerts for accepting to be the second supervisor for my thesis. Thank you for all the help.

Thirdly, I would like to thank Mr. Gerbert Coolen, for the valuable time he spent, clearly explaining the technical details involved in this thesis and for reviewing this thesis for its technical feasibility. I would also like to thank Mr. Paul Meerdink, for clearly explaining Remote Service Network and the value-addition in my networking domain.

Fourthly, I thank Mr. Pieter Mol, Mr. Fred van Mierlo, Mr. Gijs Van de Ven, Mr. Erik Visser and other colleagues from Competence Center Group and ECCC Healthcare IT group for all their support in assisting this research thesis.

Fifth, I pass-on my special thanks to friends and my family especially to Priya and Ajay - my children and Vijay - my husband, who missed several weekends, holidays, mummy's bedtime stories and coped with odd working hours. I thank my sister Dr.Sugumari Elavarasu, her husband Dr.Elavarasu and my brother Mr.Ganesh Gopal for their support.

My final thanks to my mother, Sampoornam Gettichettiar, whose remarkable life has inspired me; I dedicate this thesis to her love, affection, support and encouragement during my studies.

Er. Vadivu Vijayaraghavan, Eindhoven, May 2006.

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Executive Summary

This report describes the thesis project, performed by Er. Vadivu Vijayaraghavan, at Philips Medical Systems, Eindhoven. In recent decades IT developments have had a major force on business. The introduction of PC, LAN, client/server technology and the Internet has enabled organizations to bring their products and services to markets more quickly. These developments have ushered in the transition from the industrial to the information age. In this information age, everything has become faster and more dynamic. The same situation is applicable to Philips Medical Systems which handles the products of the Healthcare Informatics.

The subject of the thesis project is to develop a Configuration Management System (now on referred to as CMS) for the Philips Medical Systems ECCC (EMEA – Customer Care Center) Healthcare IT (HIT) team. The conceptual data design for the CMS includes description of both the software and hardware parts involved in the Healthcare IT products and solutions, and the role of the Remote Service Network (RSN), which is used to access the Healthcare IT products remotely. In the conceptual data design, basic concepts and definitions of the Information Technology Infrastructure Library[1] (ITIL) are adopted to capture the *Configuration Items*.

The ECCC group handles customer support activities for all products of the Philips Medical Systems. This group was formed in January 2005 and now has approximately 25 product specialists in support activities. Its operation is from the Eindhoven Center. A conceptual data design is developed for the HIT team to facilitate its support activities. The Competence Center (CC) group (which is concerned with installation, application and integration activities) is also closely involved in this thesis to find the technical and influencing details for the design.

The conceptual data design is developed to help the Philips Medical Systems – ECCC HIT team to improve its business process.

Basic concepts / definitions

The following definitions provide insight into various terms, used in this research topic. These definitions explain the meaning of the terms - Installed Base, Configuration Management and Configuration Items (CI's).

Installed Base : The Installed Base is the total of delivered systems, products and their versions as installed at the customer location. It includes hardware and software information to fulfill business and legal requirements

Configuration Management[2] **[Based on [7]]**: Configuration Management addresses the control

[1] ITIL- Best practice standard for IT Service Management –and are supported by, the British Standards Institution's standard for IT service Management (BS15000). http://www.itil.co.uk/

[2] Source of definition: IT Service Management – based on ITIL® , an introduction – Jan Van Bon, Mike Pieper, Annelies Van der Veen

of a changing IT infrastructure[3] (standardization and status monitoring); identifying all significant components[4] within the infrastructure; collecting, recording and managing details about the components.

Configuration Items (CI's) [5] **[Based on [7]]**: In the terminology of Configuration Management (defined by ITIL), together with IT components and the services provided by them are known as *Configuration Items* (CI's). As shown in the figure 1, CI's can include PC hardware, all kinds of software, active and passive network components, servers, central processors, documentation, procedures, services and all other IT components to be controlled by the IT organization.

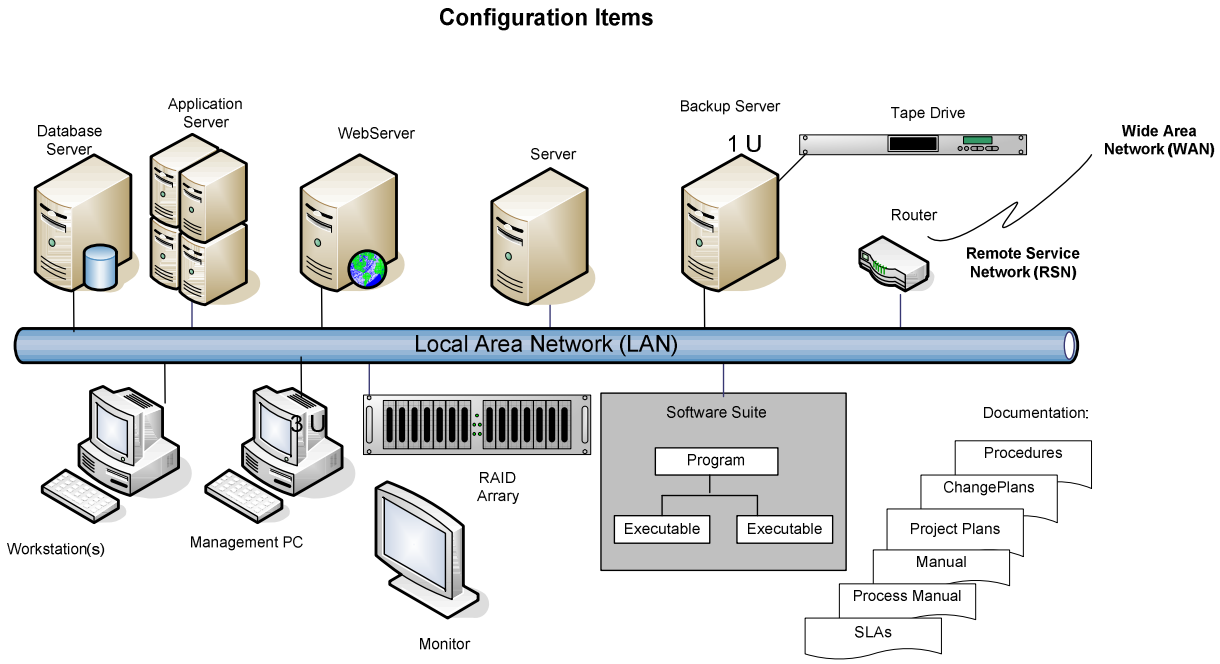

Figure 1: Configuration Items

Business reasons to perform the project

The business reasons to perform the design for the Configuration Management System are:

- Need to know the Installed Base at customer location.
- Installed Base details support the Configuration Management System.
- It is mandatory to know essential product details for health care products (including Health care Informatics) because it is a legal requirement by governments worldwide.

[3] Infrastructure (in this document) would include the application, operating system, database management system (DBMS), communications protocols, compilers and other development tools

[4] Components are such as servers, workstations, network configurations, monitors etc.,

[5] Source of definition: IT Service Management – based on ITIL®

- When the conceptual data design is implemented, it supports the handling of various business processes like entitlement, warranty, and warranty to contract conversion, contract renewal, contract maintenance, maintenance (corrective maintenance, preventative maintenance), life cycle business and field change orders (FCO). Field change orders include a category for patient safety (recalls or mandatory FCO's), which is required by governments worldwide.

Scope of thesis project

The scope of this thesis project is to develop a Configuration Management System (CMS). This design should include description of the components involved in the hardware and software parts of the healthcare IT products and solutions. Moreover it is necessary to define the role of the Remote Service Network, which is used to remotely access Healthcare IT products and solutions, in the CMS. The CMS should include the Configuration Items with their attributes. The information about these items and their attributes is to be maintained because they continuously change during upgrading, replacement or maintenance.

Thesis Assignment Problem Description

The Healthcare IT products and solutions are 'One-Of-A-Kind Production' when compared to the other products of Philips Medical Systems. This is due to the fact that each and every product delivery is a 'Designed Solution', customized to the customer specification. This means that each and every product is different from the other.

The research involves investigating and finding the *configuration items* in software and hardware parts. These items are supplied mostly by the external suppliers. Each supplier has its own way of taking the order from their customer and delivering them. Some suppliers do not have a part ID to identify the part. In this case, Philips Medical Systems orders the part by their name and / or by the model number. Because of this situation, at present, there is a problem in tracing the parts in the Healthcare IT products.

At present while ordering the parts to the external suppliers, the 'mat. Number' referred in the 'List Of Purchasable Items (LOPI)' are inconsistent. This makes it difficult to trace the items.

The parts are delivered to the Philips Medical Systems by the external suppliers. They are assembled inside Philips Medical Systems and / or by Sales Service Districts[6] (SSD). When a final solution has been built the product is delivered to the customer. During this process, the serial number and installed base details are not recorded for all the parts. This causes to a problem in the Installed Base Management.

Moreover, changes in the products and solutions are not only applied by the Philips Medical

[6] This is a term Philips Medical Systems uses to represent Philips Organization in countries responsible for Sales and Service activities.

Systems but also by the customer in the Installed Base. Thus the impact on the configuration is affected by the customer too. This is an uncontrollable situation.

Approach to solve the problem

It is evident that the above mentioned problems mainly arise due to the fact of improper recording of the Installed Base details causing problem in business process.

What are the essential requirements to solve this problem? The first requirement is proper identification of the parts. Second, the installed parts details should be documented. Thirdly, these parts' serial numbers and versions should be recorded for the Configuration Management System.

The problem description mentioned above leads to the following activities;

1. Find the relevant variables to build the solution of a Healthcare IT products and solutions.
2. Find the attributes for the Installed Base.
3. Find the attributes which are maintained for the Configuration Management.
4. Find the attributes which are in the Remote Service Network and can be used in the CMS further on.
5. Combine steps 1, 2, 3 and 4 and build a design in the Unified Modeling Language – Class diagram as a data model.
6. Develop a prototype database to illustrate some real data and verify the 'Conceptual Data Design'.

Previous sections provide the business reasons to perform this project, its scope, assignment and requirements to solve the problem. Now, it is time to investigate how to solve the problem. In order to solve the problem in depth technical knowledge should be gained with Healthcare IT products and solutions. Therefore, various documents from the back-office, site assessment and integrated test facility documents for various concrete projects from the Competence Center application group are read and used to get in depth knowledge about the HIT products and solutions.

Various books in the 'References' were read and I decided to use the approach by ITIL™ because it provides the information of best practices in IT Service Management, which is a British Standard. This project thesis is also conducted in the same IT Service Support scenario. The best practices approach by the ITIL™ helped to identify the *configuration items* of software and hardware parts.

What model can be used to design?

For designing a CMS, a design methodology has to be decided and so various possibilities, questions are investigated. In the end the possibility of making expressing the design in Unified

Modeling Language is investigated and I decided to record the design in a UML class diagram. The class diagram is used to represent the static data model and widely used in IT domain.

How to verify the design?

The Conceptual Data Design has been verified by developing a prototype database which is illustrated with some real data.

How to validate the design?

The design is validated by formulating questions. This facilitates the stakeholders to validate and thus the conceptual data design is validated.

Thus the conceptual data design developed for the Configuration Management System which improves the business process of ECCC – HIT team in its support activities. This design includes descriptions to be recorded for the Installed Base Management. These descriptions together with the technical configuration provide the CMS. The conceptual data design can be used as a base to build a tool or to implementation in the SAP database. The design provides all technical details which are required for the Configuration Management.

1. Company Description

This chapter briefly introduces the company and the environment in which the project is carried out. The environment explains the cause of the problem and the constraints of the solutions.
This research thesis is conducted in the Philips Medical Systems with the purpose to design a Configuration Management System for the Philips Healthcare IT products and solutions.

1.1 Royal Philips Electronics

Royal Philips Electronics or (Philips) of The Netherlands was established in 1891 as a lamp factory. Today it is Europe's largest and one of the world's biggest electronics companies. It has a multinational workforce of over161, 000 employees in over 60 countries.

Philips is active in over 60 businesses, and with more than 115,000 registered patents, it is currently number 1 in the global markets for lighting, electric shavers and DVD recorders. And it is number 2 in medical diagnostic imaging worldwide. Within the cyclical goods market, "Dow Jones" recently ranked it the global leader in sustainability.

In a world in which technology increasingly touches every aspect of daily life, Philips wants to bring 'Sense & Simplicity' to consumers with advanced, easy to use products that are designed specifically to meet their needs. Philips will do this by focusing on the areas of Healthcare, Lifestyle and Technology.

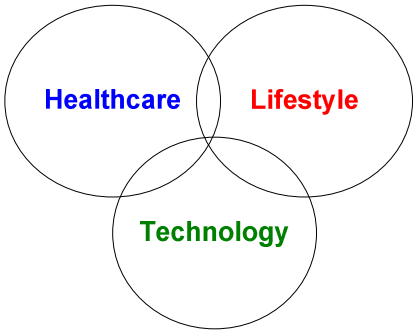

Figure 2 : Royal Philips Electronics –'One Philips'

Gerard Kleisterlee, president and CEO (Chief Executive Officer) of Philips, has announced previous year, the strategic direction of 'One Philips'. This 'One Philips' program aims at bringing together all the product divisions (PD's) within the company. They are clubbed together under three categories namely, healthcare, life style and technology. The idea is to share a common ground that underpins the brand, the technological core competences, the financial basis, the shared support functions between the cross PD's.

Philips is active in about 60 businesses, which are divided into 5 main product divisions:

- Medical Systems

- Domestic Appliances & Personal Care
- Consumer Electronics
- Lighting
- Semiconductors

1.2 Philips Medical Systems

Philips Medical Systems (PMS) founded in 1896 when Philips manufactured the first x-ray tubes for medical applications. In1998, Philips launched a Healthcare Services group dedicated to the advancement of healthcare technology that meets the specialized needs of clinicians as well as patients. Philips Medical Systems is well positioned to transform the healthcare possibilities of tomorrow into the realities of today.

Philips Medical Systems (PMS) is a leading supplier of diagnostic imaging equipment, information technology and related healthcare services. Jouko Karvinen is the president and Chief Executive Officer of PMS. Approximately 30,600 (19% of total Philips Electronics) employees are working in PMS with sales and service operations in 63 countries with over 6,000 service technicians. Philips Medical System's organization:

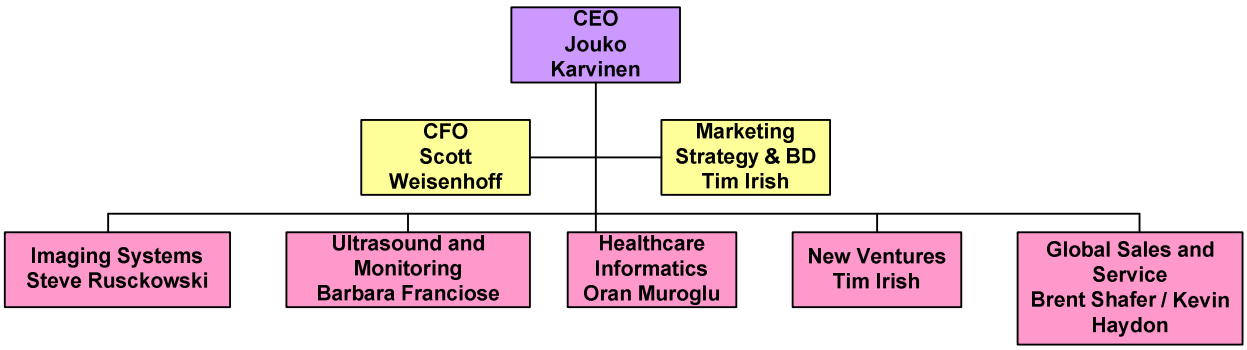

Figure 3 : Philips Medical Systems Businesses (Source: Philips Medical Systems)

The business division, where this thesis is performed is under the main organization Global Sales and Service division.

PMS's product line includes best-in-class technologies in [5]:

- X-ray
- Ultrasound (US)
- Magnetic Resonance Imaging (MRI)
- Computed Tomography (CT)
- Nuclear Medicine (NM)
- Positron Emission Tomography (PET)

- Radiation Oncology Systems
- Patient Monitoring (PM)
- Information Management
- Resuscitation products
- Cardiac Monitoring Systems
- Cardio Vascular Care
- Healthcare Informatics

The Healthcare Informatics portfolio includes a wide range of products and professional services, each one offering customer tailored image and information management solutions for the Cardiology as well as the Radiology environment. This thesis covers both the Radiology and Cardiology IT products and solutions.

PMS also offers a wide range of services including, training and education, business consultancy, financial services and e-care business services.

1.3 EMEA Customer Care Center – Healthcare IT Group

The EMEA Customer Care Center – Healthcare IT (HIT) team (this team from now on referred to as HIT team), a division of the Customer Services, is rapidly increasing the number of its support engineers. This is the division where the work of this thesis was performed is in The Netherlands. This group was formed in January 2005 and is taking over the major call screening which has been handled by the Competence Center (CC). The present tasks of this group are to handle major call screening from the customers and to improve and extend the remote service in Europe Middle East and Africa (EMEA) region. This group provides the following major services:

- On site support activities with or without installation
- Tier 1 support: call screening, and qualification and remote support activities for customer calls
- Tier 2 support: specialist and remote support activities for Field Engineer.
- Increase the customer satisfaction by speed and quality of services mainly performed via Remote Service Network.
- Installation Support.
- Remote monitoring.
- Technical call screening and Technical support.
- ECCC supports solutions during lifetime of the product.

Figure 4 shows the organization of the ECCC group:

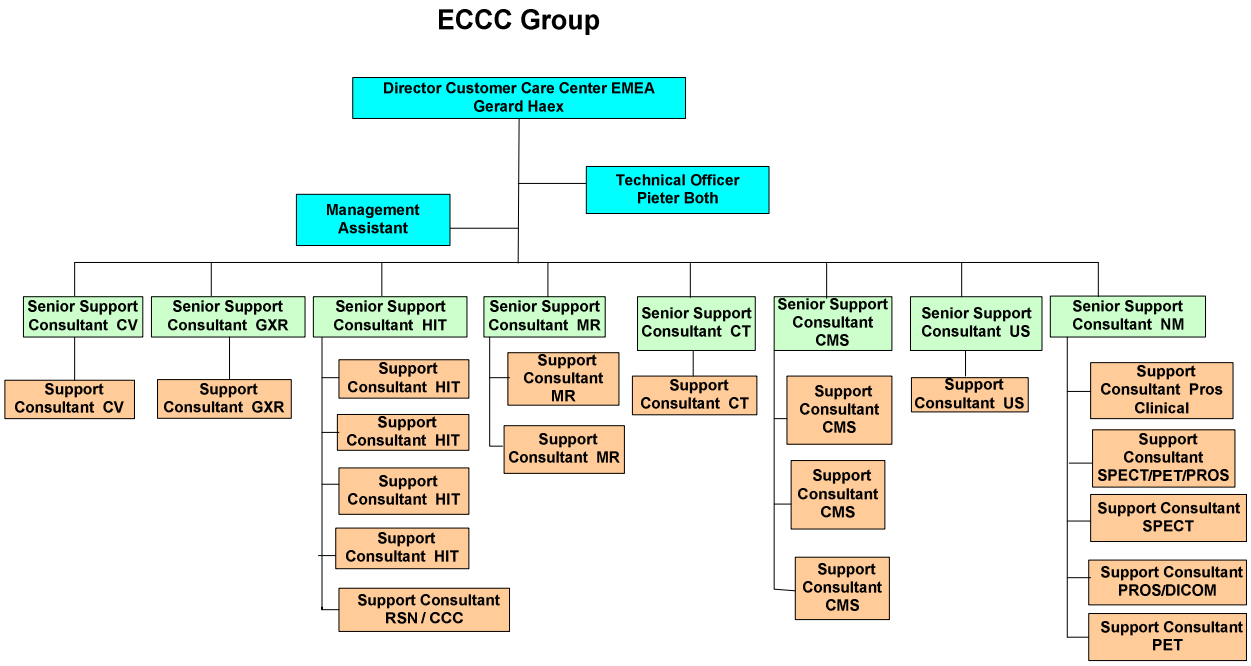

Figure 4: ECCC group – Organization Chart (Source: Philips Medical Systems)

Healthcare IT group covers following range of products for its services:

- EasyVision MR / CT/ X-Ray / RAD
- Rados / RIS
- EnConcert
- ViewForum
- EasyAccess products
- Easy RIS
- Xcelera / Xcelera Cath Lab Management
- EasyLink
- EasyWeb

Healthcare IT solutions help healthcare organizations to manage, support and deliver patient records during all episodes of a patient's lifetime.

Philips Healthcare IT provides fully integrated, enterprise-wide patient information solutions. The products and solutions address a wide range of healthcare IT needs, connecting the complete hospital information management. Comprehensive management of a patient from diagnosis through treatment is supported by a single Electronic Health Record, making all the relevant clinical patient information available in the various hospital departments, such as radiology, cardiology departments and beyond.

1.4 Competence Center (CC) Group

During the period of the thesis, technical product knowledge is gained from the Competence Center group. This group deals with the same products mentioned in the Healthcare IT group. Figure 5 shows the organization chart of Competence Center Group.

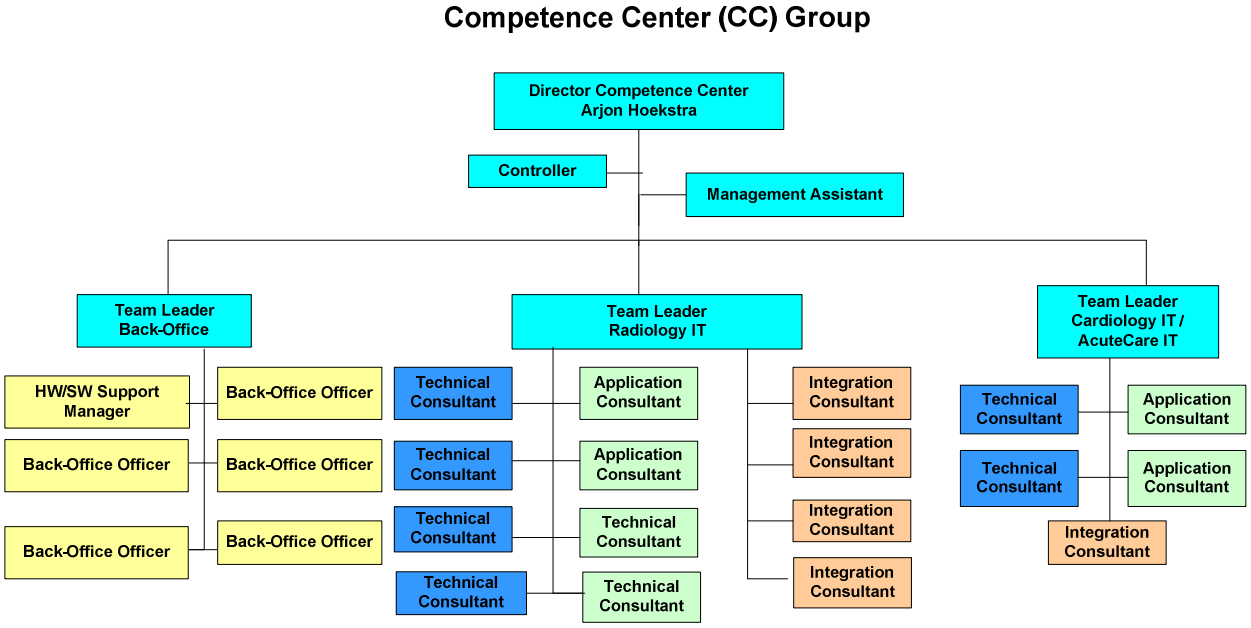

Figure 5 : Competence Center group – Organization Chart (Source- Philips Medical Systems)

The mission of Competence Center group [6] is to become a reliable and highly qualified solution provider for the Europe Middle East and Africa country teams and to the Customer Services organizations by providing professional technical, application, integration and consultancy services to meet the Healthcare IT business objectives and to satisfy customers in the area of Radiology IT, Cardiology IT and Acute Care IT.

Competence Center's main services are:

- To develop and implement advanced system concepts in Healthcare IT Products
- To integrate Medical IT products in complex IT environments
- To integrate Medical IT products with 3rd party information systems like Electronic Patient Record, HL7 (Health Level 7 standards) and DICOM (Digital Imaging and Communications).
- Upgrade and Migration services (like Data migration of clinical data to new generation systems and to upgrade to new releases or enterprise systems)
- Initiate and steer First of a Kind projects (New product / version launch)

- 2nd line helpdesk support for Customer Care Center
- Pre-staging (In-house assembling) and implementation of standard solution offering
- Clinical workflow support
- Hardware / Software purchasing support for IT projects

Thus a small introduction about the organization of Philips Medical Systems is provided. The organization and present functions of the CC and ECCC group is provided to describe the basic scenario of where this thesis problem description is found.

2. Research Approach

This chapter describes the research approach in detail. The previous chapter described the environment of the Philips Medical Systems and the organization of the ECCC group in which the project has been conducted. It discusses in detail the basic definitions used in this thesis and current situation in ECCC group which lead to this research project. It describes the business reasons to perform this project with the problem description and assignment. The research questions and research model is built upon the problem description. The argument for the design approach is explained. Then scope and limitations for the project is described with the research deliverables.

2.1 Basic Definitions

Following are the definitions that provide an insight into the research topics - namely Installed Base and Configuration Management.

Installed Base : The Installed Base is the total of delivered systems, products and their versions as installed at the customer location. It includes hardware and software information to fulfill business and legal requirements.

Configuration Management[7] **[Based on7]]**: Configuration Management addresses the control of a changing IT infrastructure[8] (standardization and status monitoring); identifying all significant components[9] within the infrastructure; collecting, recording and managing details about the IT components.

Configuration Items (CI's) [10] **[Based on 7]]**: In the terminology of Configuration Management (defined by ITIL), together with IT components and the services provided by them are known as *Configuration Items* (CI's). As shown in figure 1, CI's can include PC hardware, all kinds of software, active and passive network components, servers, central processors, documentation, procedures, services and all other IT components to be controlled by the IT organization.

[7] Source of definition: IT Service Management – based on ITIL® , an introduction – Jan Van Bon, Mike Pieper, Annelies Van der Veen

[8] Infrastructure (in this document) would include the application, operating system, database management system (DBMS), communications protocols, compilers and other development tools

[9] Components are such as servers, workstations, network configurations, monitors etc.,

[10] Source of definition: IT Service Management – based on ITIL®

2.2 Current situation in ECCC Healthcare IT and Competence Center group

In this section, the current situation in Philips Medical Systems– ECCC HIT team (from now on referred as to HIT team) and Competence Center (CC) group are described.

Presently the HIT team and Competence Center (CC) work closely in support activities for the Healthcare IT products and solutions. Technical and Integration consultants from Competence Center group support the Technical Support Specialists in the HIT team with regard to technical and installed base management information.

The HIT team supports and solves the customer issues mostly by the Remote Service Network. The Remote Service Network allows access to customer network remotely. Technical support specialists from the HIT team gather information about the hardware and software (like release, version and level / patch) details from:

- Technical and / or Integration consultants from Competence Center group
- Customers
- Previous support archive details
- By remote access to the system

Once the information is gathered, the problem is solved by remotely connecting to the server and / or workstation. Most of the issues are resolved with remote-assistance; but when they are not, a support specialist is dispatched to the customer location.

In the above mentioned process, most of the time 5 – 10% is consumed in gathering currently available configuration information of the hardware and software parts at the customer's location. A Configuration Management System can be profitable in reducing this time to less than 1%.

The Configuration Management System which is developed during this thesis, when implemented helps the Technical Support Specialists in their support activities and improves the business process of ECCC group.

2.3 Business reasons to perform the project

The business reasons to perform a data design for the Configuration Management support system are:

- To know the Installed Base at customer location.
- Need to know the Installed Base details to support the Configuration Management System.
- It is mandatory to know essential product details for healthcare products (including Healthcare Informatics) because it is a legal requirement by governments worldwide.
- When the designed Configuration Management System is implemented, it supports the handling of various business processes like entitlement, warranty, and warranty

to contract conversion, contract renewal, contract maintenance, maintenance (corrective maintenance, preventative maintenance), life cycle business and field change orders (FCO). Field change orders include a category for patient safety (recalls or mandatory FCO's), a regulation required by governments worldwide.

2.4 Problem Description

The Healthcare IT products and solutions are 'One of a Kind production' when compared to the other products of the Philips Medical Systems. This is due to the fact that each and every product delivery is a 'Designed Solution', customized to the customer specification. This means that each and every product is different from the others.

The research involves investigating and finding the *configuration items* in software and hardware parts. These items are supplied mostly by the external suppliers. Each supplier has its own way of taking the order from their customer and delivering them. Some suppliers do not have a part ID to identify the part. In this case, Philips Medical Systems orders the part by their name and / or by the model number. Because of this situation, at present, there is a problem in tracing the parts in the Healthcare IT products.

At present while ordering the parts to the external suppliers, the 'mat. Number' referred in the 'List Of Purchasable Items (LOPI)' are inconsistent. This makes it difficult to trace the items.

The parts are delivered to the Philips Medical Systems by external suppliers. They are assembled inside Philips Medical Systems and / or by Sales Service Districts[11] (SSD). When a final solution has been built the product is delivered to the customer. During this process, the serial number and installed details are not recorded for all the parts. This causes to a problem in the Installed Base Management.

At present, some of the Installed Base details can be obtained from the 'Integrated Test Facility' document created by Competence Center group. In some instances, the Installed Base details are obtained from the customer itself. During the upgrading, replacement or maintenance of parts, the information is stored locally by the 'Sales Service Districts'. The change in the configuration is not stored in a unique accessible database. This leads to the problem getting bigger in the Configuration Management.

Moreover, changes in the products and solutions are not only applied by the Philips Medical Systems but also by the customer in the Installed Base. Thus the impact on the configuration is affected by the customer too. This is an uncontrollable situation.

[11] This is a term Philips Medical Systems uses to represent Philips Organization in countries responsible for Sales and Service activities.

The following Figure 6 explains the incident (refer definition Incident Management -Chapter 4.1.1) escalation as defined by ITIL [7]. This picture also explains the first-line support and second-line support.

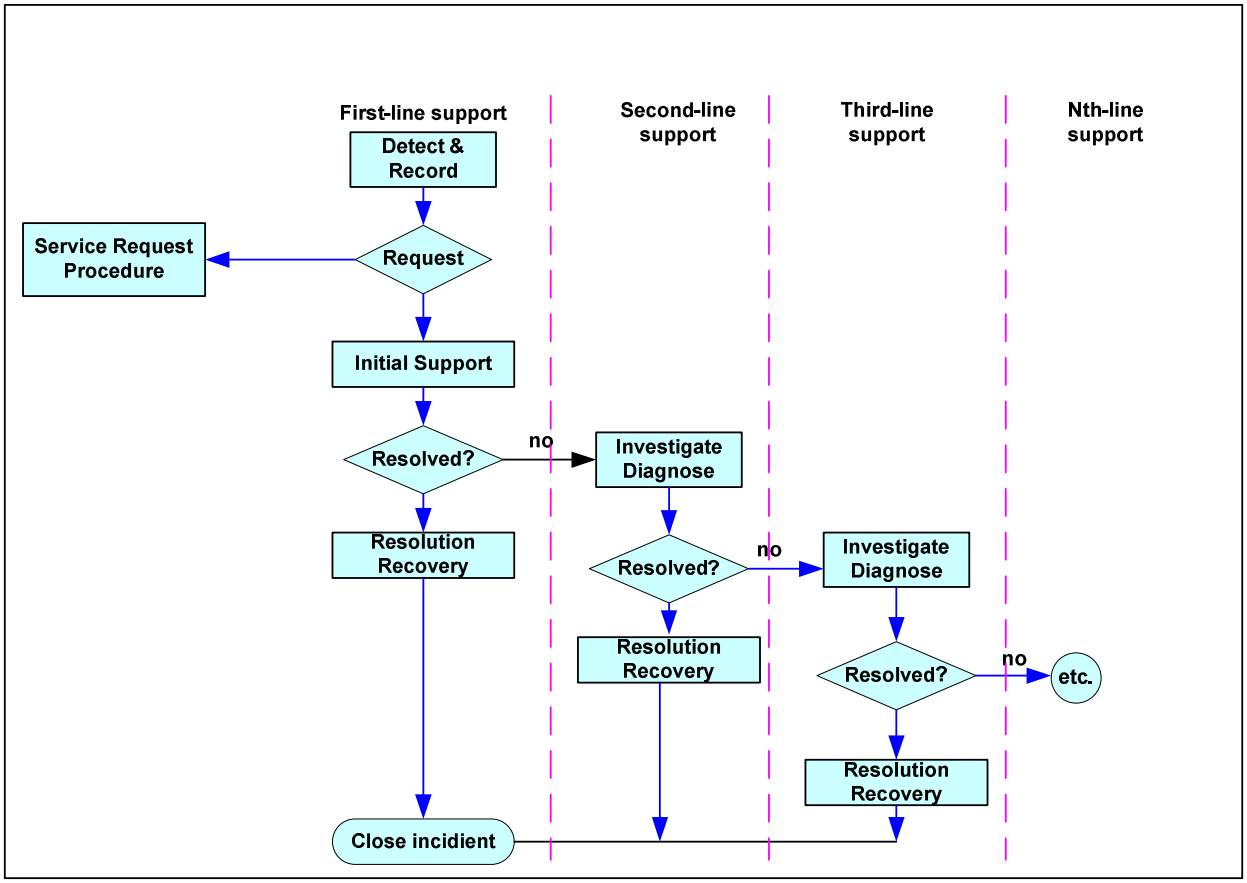

Figure 6: Incident escalation (Source: [7]). 'Nth-line' is also known as 'Tier N'

In the figure 6, the process 'Detect & Record', 'Investigate Diagnose' needs the Installed Base details for support activities conducted by HIT team.

2.5 Research questions

The key question that was formulated at the outset of the research of this report is as follows:

"*Design a Conceptual Data Model for an Installed Base and Configuration Management System for the Philips Healthcare IT Products and Solutions*"

To structure the research process, this relatively broad question has been broken down into various sub-questions that rendered the work into more manageable tasks. By answering the sub-questions the overall question are addressed.

The following are the basic questions to understand the research topic

- What is the Installed base?
- What is the Configuration Management?
- What information is essential to the Installed Base Management?
- What are the current issues in Installed Base Management?
- What attributes are identical for the Configuration Management System?
- How does Remote Service Network help the Configuration Management System?
- What is the improved process model when the Configuration Management System is implemented?

The following activity helps to design the data model for the Installed Base and Configuration Management Systems of Healthcare IT products and solutions:

1. Find the relevant variables to build the solution of a Healthcare IT products and solutions.
2. Find the attributes for the Installed Base.
3. Find the attributes which are maintained for the Configuration Management.
4. Find the attributes which are in the Remote Service Network and can be used in the CMS further on.
5. Combine steps 1, 2, 3 and 4 and build a design in the Unified Modeling Language – Class diagram as a data model.
6. Develop a prototype database to illustrate some real data and verify the 'Conceptual Data Design'.

2.6 Research Model

This section elaborates the phases of the project. Figure 7 shows a detailed research model. Activities pertaining to design the data model are carried out. The verification and validation of the design is conducted in the 'verification and validation' phase.

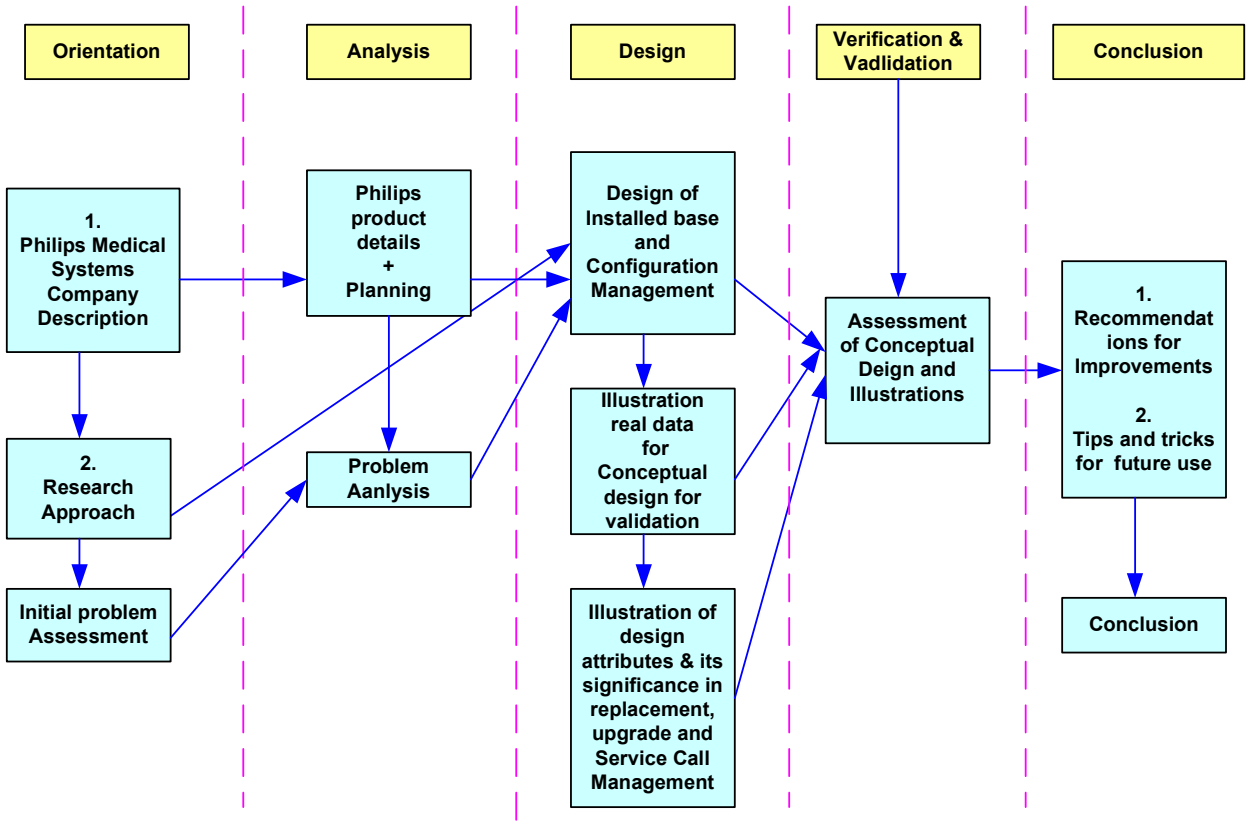

Figure 7: Research Model

The activities in this model have been performed by using a range of research methods and techniques, as mentioned below:

- ➔ Literature research using books and articles as the primary sources for having insight knowledge in the related Healthcare IT domain.
- ➔ Initial discussions with Technical Support Specialists from HIT team during orientation and analysis phase.
- ➔ Structured discussions with Technical Consultant(s) from Competence Center group at various levels during orientation, analysis, design and verification and validation stage.
- ➔ Interviews, discussions and information gathered from the Back-office Officers and manager from the Competence Center group.
- ➔ Analysis and study from various project files from Back-office Competence Center.
- ➔ Investigation and analysis of documents Integrate Test Facility (ITF), Site Assessment documents, List of Purchasable Items (LOPI s) for various projects of Healthcare IT products and solutions.
- ➔ Design details for the data model are extracted from the above mentioned documents.

The research begins with basic knowledge gaining phase of Healthcare IT products and solutions. During which literature study is carried-out using various search engines available in

Technical University Eindhoven and web analysis of competitors of the Philips Medical System and a report (Appendix 4) is submitted in the earlier phase of the project. This study includes several books namely:

- *Remco W. Helms*,' Product Data Management as enabler for Concurrent Engineering'

Frank B. Watts,' Engineering Documentation Control Handbook'- Configuration Management in Industry, Second Edition.

As a start of this project, the Philips Medical Systems and the ECCC group (where this project thesis was conducted) organization are studied. Then the research approach with initial problem description is investigated. Meanwhile the present situation in the ECCC group and CC group also investigated. This investigation facilitates to define the scope and limitation of the project with research question.

During this phase of the project, the first two months, product knowledge of the healthcare IT products is acquired by the author. Product knowledge is gained by discussions with the Technology Officer, Back-office Manager, Back-office Assistants, Logistics assistant, Technical Support specialist, Application specialist, Implementation specialist, Integration specialist and self-study. During self-study, several project files from back-office, site assessment and integrated test facility documents are analyzed and investigated.

2.7 Design Approach

This section provides the argumentation for selecting the 'Conceptual Data Design' for the data model. The Conceptual design means that the data model can be used in more generic way. The data design is a static model which can be used to get the information of the Installed Base details. By deciding the conceptual model, the model can be further easily used for implementation in any database management system. The reason for not deciding for the data model in the SAP because the HIT team uses an Installed Base Management system in the SAP. This system cannot be altered at this moment. So it is will not be useful to design a data model in SAP which will not be implemented further in SAP by the HIT team. But at the same time, the conceptual design will facilitate to provide information for Configuration Management System when the HIT team decides to use the SAP for the Configuration Management.

Moreover the conceptual data model can be used by any database management system. This data model provides the configuration management system which helps to record the Installed Base Management as well as supports the Configuration Management. The reason to decide the conceptual data model is to first provide the information for the CMS after which the HIT team will decide how to implement the conceptual data model.

2.8 Scope and Limitation of the Research

The scope of this thesis project is to develop a Configuration Management System (CMS). This design should include description of the components involved in the hardware and software parts of the healthcare IT products and solutions. Moreover it is necessary to define the role of the Remote Service Network, which is used to remotely access Healthcare IT products and solutions, in the CMS. The Configuration Management System should include the Configuration Items with their attributes. The information about these items and their attributes is to be maintained because they continuously change during the upgrading, replacement or maintenance.

Basically, this design should include all configurable items (CI's) that are essential for the CMS and to develop a prototype database to verify the 'Conceptual Data Design' with some real data. The identified attributes in the 'Conceptual Data Design' are rated for their importance for replacement, upgrading and service call management. Process flow is identified to identify the stakeholders in the Competence Center (CC) group. The captured attributes from the conceptual data design are identified for their source, where and when they arrive in process flow of the CC Group.

Implementing the Configuration management system is not in the scope of this project.

During the period of this project thesis, the above mentioned activities are covered and the deliverables are mentioned in the next section 2.9.

2.9 Research Deliverables

The main deliverables of this research project thesis are as follows:

D1. Conceptual Data Design for an Installed Base and Configuration Management System.
D2. A prototype database with some real data to illustrate which verifies the Conceptual Data Model.
D3. Illustration attributes - relevance for replacement, upgrading and service call management.
D4. 'Process Flow – EMEA – Call Handling – Maintenance'

Note that the deliverables D2 and D3 are delivered as separate files. D2 file is delivered in the Microsoft Access and the name is "PrototypeDatabase.mdb"and D3 file as "Attributes_Replacement_Upgrade_ ServiceCallManagement.xls". In section 5.5 'Design Conclusion', few examples are taken from the above mentioned files and explained in detail.

The 'Conceptual Data Design' provides the information to the HIT team to implement the Configuration Management System. An illustration of a prototype database with some real data verifies the conceptual data design. The design attributes are investigated for its relevance in case of replacement, upgrading and service call management. Process flow is in the conclusion of the chapter 5 'Design'. This chapter provides the improved process flow for the service call handling process.

2.10 Phases in the Project and overall Structure of the Report

In line with most recommended practices, overall project management has been divided over five phases as depicted in figure 8. These phases are as follows:

Orientation Phase

In the orientation phase, Philips environment and organization structure with their functions are explored, which contributes to the first chapter: Company Description. The research perspective is established with the research objective, questions, scope and limitations. This contributes to the detailed Chapter 2: Research Approach.

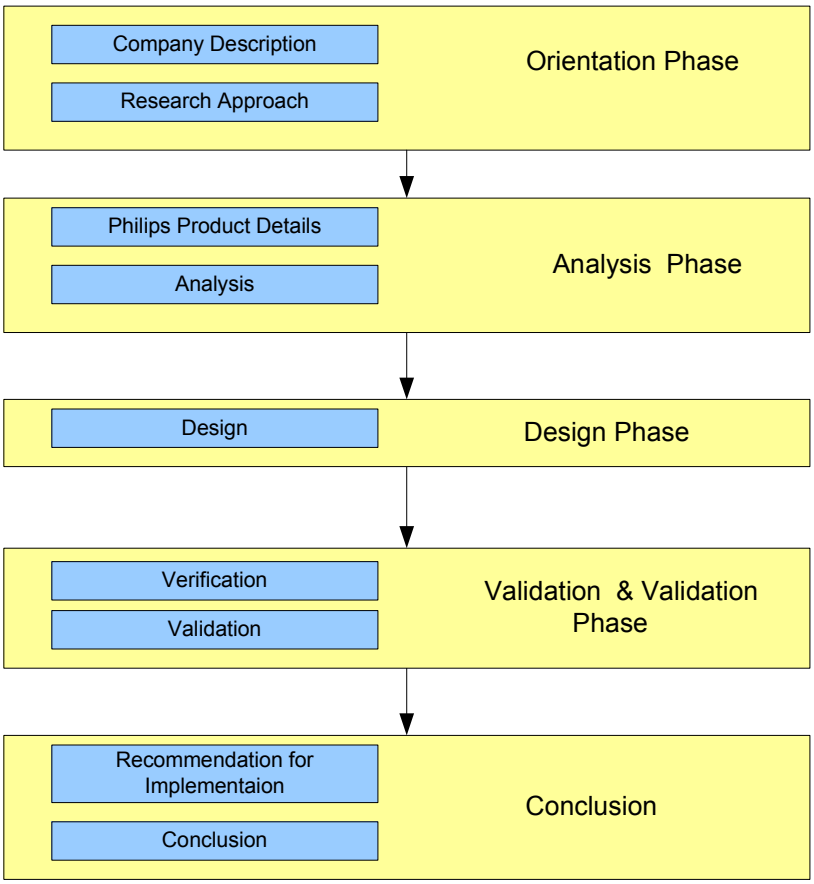

Figure 8: Phases of Project

2.10.1 Analysis Phase

In the requirement analysis phase, the literature study and product knowledge gaining phase from different groups required for the research are addressed in Chapter 3: Philips Healthcare IT – Product details. Analysis phase: Chapter 4 contributes to the identification and detailing the

Configuration Items.

2.10.2 Design Phase

Design phase contributes to Chapter 5 which presents the data model for the Configuration Management System. It contribute the process flow of the stakeholders.

2.10.3 Verification and Validation Phase

Chapter 6 contributes to the verification and validation of the Conceptual Data Design. The design is verified by developing a prototype database with some real data. The data model is validated by the stakeholders for the correctness of the model.

2.10.4 Conclusion Phase

This phase includes the recommendations and conclusion. Chapter 7 provides the recommendation for implementation with tips and tricks. Chapter 8 provides the overall conclusion.

3. Philips Healthcare IT – Product Details

Introduction

This chapter provides a broad insight into most of the aspects that were needed for this research. The product details are supportive to obtain focus and direction for the research.

Several hospitals have made enormous investments in a variety of Healthcare Information Systems. For example, the few Healthcare Information Systems are HIS (Hospital Information System), LIS (Laboratory Information System), CIS (Clinical Information System), RIS (Radiology Information System) and PACS (Picture Archiving and Communications System). The main purpose of these systems is to make an isolated solution for each functional department in a hospital, and these isolated systems can run effectively in each area. However no single company or single information system can meet all of the information management needs of a healthcare enterprise, let alone all the requirements for a truly complete, distributed, national and international electronic medical record. Therefore, Information systems must communicate with each other to successfully accomplish complex healthcare processes.

Since the diversified Healthcare Information Systems are developed in various programming languages, run on diverse platforms, based on different communication protocols, some provide API (Application Programming Interface) while others do not, etc., integrating these information systems is rather complicated. The formulation and popularization of HL7 (Health Level 7, explained in detail in section 3.1) and DICOM (Digital Imaging and Communications in Medicine), the healthcare data exchange standards, have greatly improved the way computer systems in healthcare share information.

3.1 Hospital workflow

The Figure 9 shows an information flow process model in the hospital. The Hospital Information System (HIS) checks the availability of the patient data (for example, patient name, date of birth, house address etc.,) and updates them if available; or else, a new record is created.

When a patient is approved by the doctor for an examination in the radiology department, the patient data is sent from the Hospital Information System via the Radiology Information System (RIS) to the modalities (modalities means X-ray, Computed Tomography – CT and/or Magnetic Resonance Imaging -MRI machines). The Philips product for the Radiology Information System, called EasyRIS, has been launched recently. The product used earlier was Radors. Work-lists generated by Radiology Information System are sent to the modalities like X-ray, CT and MR via Health Level 7[12] standards (HL7) through the 'Broker Interface'. The Philips broker

[12] Health Level Seven is one of several American National Standards Institute (ANSI) accredited Standards Developing Organizations (SDOs) operating in the healthcare arena. Refer http://www.hl7.org/ for more information.

interfaces are EasyLink and MergePort. The broker interface establishes the connection between the RIS (Radiology Information System) and Picture Archiving and Communication Systems (PACS). The different modalities (like X-ray, Computed Tomography, Magnetic Resonance machines) use the Philips software product called EasyVisionRAD and ViewForum as workstation's user-interface.

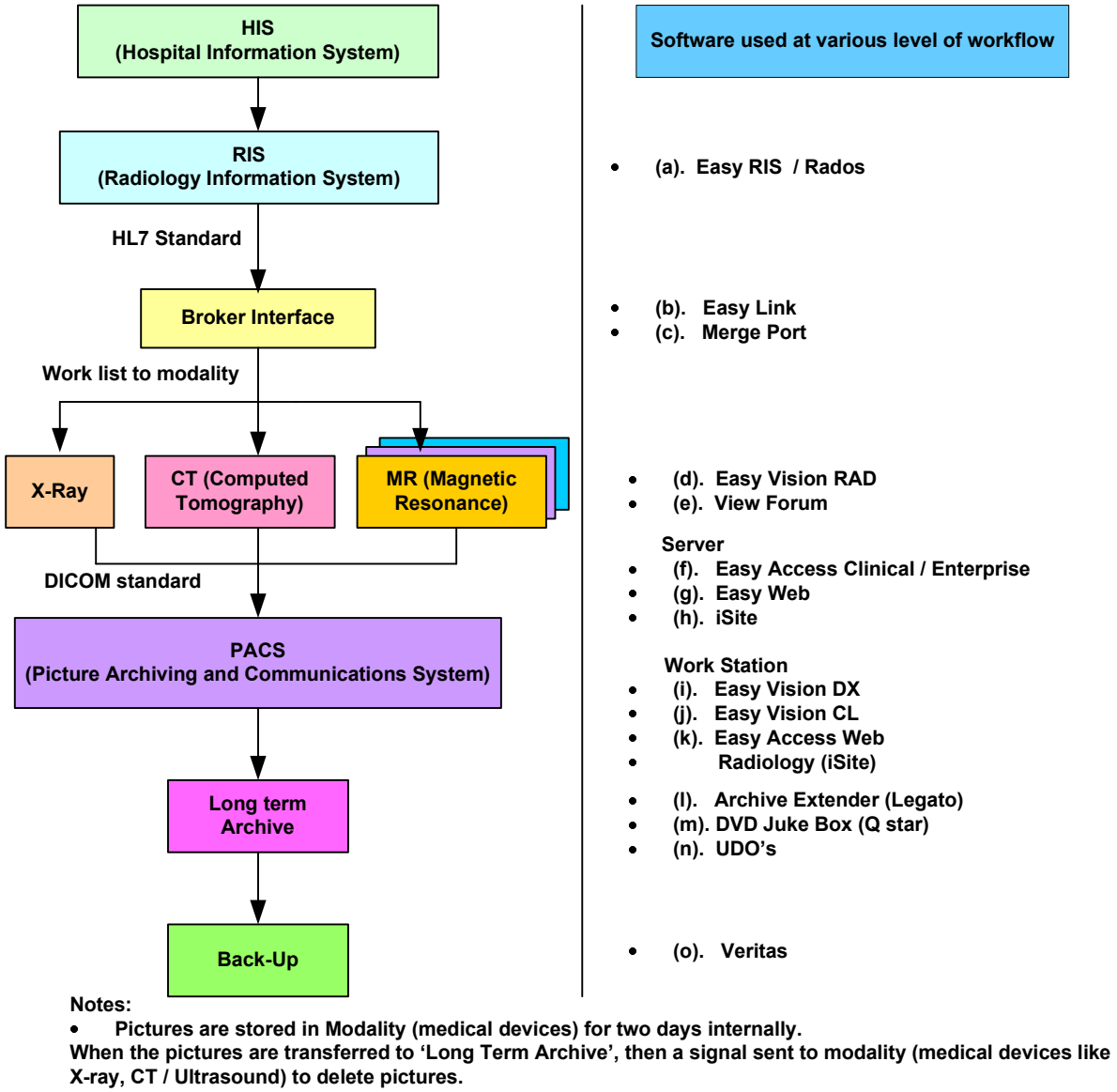

Figure 9: High Level Hospital Information Flow

Pictures taken from the patients and produced by modalities (from any machine - either an X-ray, CT or MRI machine) are transferred to the Picture Archiving and Communication Systems

(PACS) as per Digital Imaging and Communications in Medicine (DICOM)[13]. PACS has a built-in client-server architecture. The Philips PACS server uses the Philips software product EasyAccess and iSite. The client uses the Philips software EasyVision DX, EasyVision CL and EasyAccessWeb. The iSite uses its viewing station called Radiology (iSite) as user interface.

Pictures are stored in modalities for a brief period, for instance two days (depending on their memory capacity) and then transferred to the PACS server. Small hospitals use Philips software EasyAccess Clinical which is a 'single server' PACS system, often handling both the database and images (see figure 10). In large hospitals, the Philips software EasyAccess Enterprise can be used. It can be a 'multi server' PACS system. Every modality has its own image server and a separate server takes care of the database (see figure 10).

In large hospitals, long term archiving is done, for which Legato Archive Xtender and DVD Jukebox and a UDO's (Ultra Density Optical – a product type name) are used. For back-ups Philips uses Veritas.

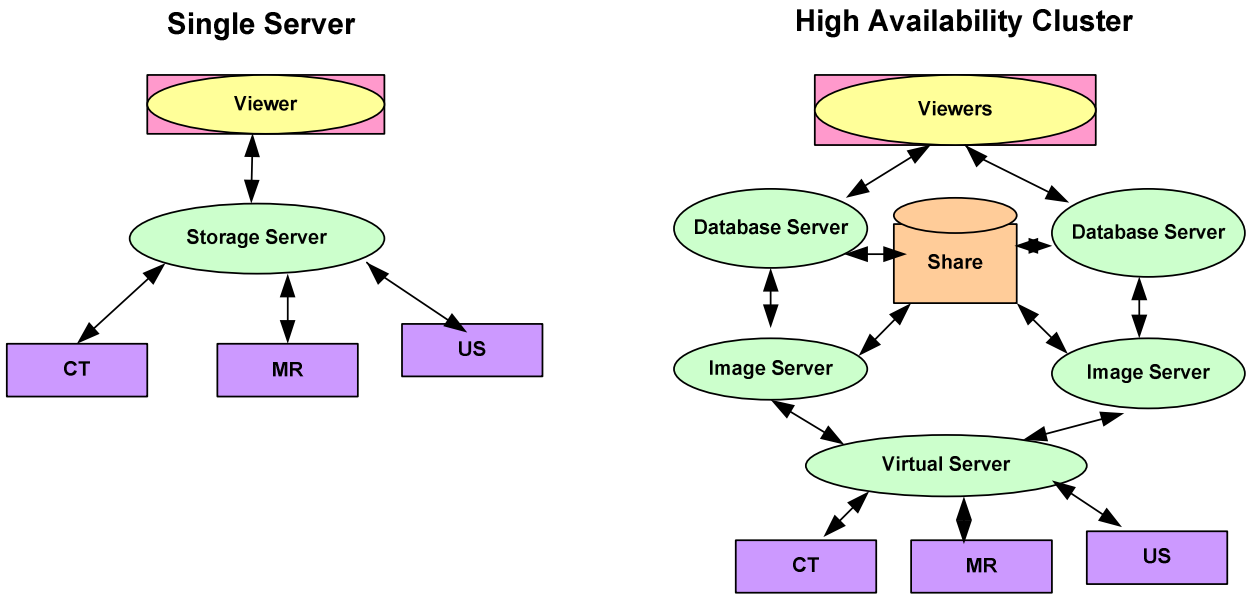

Figure 10: Single and Multi Server PACS System (Source: Philips Medical Systems)

[13] DICOM is an application layer network protocol for the transmission of medical images, waveforms, and ancillary information. Refer http://medical.nema.org/dicom/2004.html for more information.

3.2 Hospital Information System

A hospital information system (HIS) is a comprehensive information system dealing with all aspects of information processing in a hospital. This encompasses human (and paper-based) information processing as well as data processing machines. The aim of an HIS is to achieve the best possible support of patient care and administration by electronic data processing. It can be composed of one or few software components with special specific extensions as well as of a large variety of sub-systems in medical specialties (e.g. Laboratory Information System, Radiology Information System).

In Philips Healthcare IT group, Hospital Information System is not in its product portfolio. So this part will not be covered in this thesis.

3.3 Radiology Information System (RIS)

A Radiology Information System (RIS) is used by a radiology department to store and distribute patient radiological data and imagery. The system generally comprises patient tracking and scheduling, result reporting and image tracking capabilities. Refer to the figure 8 - patient data for scheduled exams are sent from the HIS (Hospital Information System) via EasyLink or RIS to the modality (like X-ray, Computed Tomography and Magnetic Resonance machines).

3.3.1 Broker Interface - EasyLink

Assessing RIS (Radiology Information System) information offers a number of well-known workflow benefits, such as timely availability of pertinent exam and patient data at appropriate work-spots. However, in a multi-vendor, multi-network world, the solution – separate interfaces with individual communication standards, and varied maintenance and upgrade requirements – often creates more problems than it actually solves.

Philips software product EasyLink provides a single, standardized connection to RIS (Radiology Information System). Easy Link offers a number of RIS interfaces that can connect RIS system to Philips PACS (Picture Archiving and Communication System) and modalities[14] (like X-ray, Computed Tomography and Magnetic Resonance machines). The reliable connection EasyLink simplifies RIS/Philips PACS connection by serving as one, central entry-point for RIS information that must be transmitted to and from the Philips PACS, Philips EasyWeb or to other modalities (like X-ray, Computed Tomography and Magnetic Resonance machines).

EasyLink enables Philips PACS to:

- Check patient data, helping avoid image labeling errors
- View report with images
- Exchange status information

[14] Philips modalities with a RIS interface and non-Philips modalities with a Digital Imaging and Communications in Medicine (DICOM) work-list RIS-interface

- Pre-fetch examinations

In combination with EasyWeb, both images and reports can be viewed remotely.

3.4 Cardiology Information System (CIS)

Cardiology Information System (CIS) is used by cardiology departments in hospital to store and distribute the patients' cardiology data and imagery. This system comprises patient tracking and scheduling, result reporting and image tracking capabilities. Patient data for scheduled examinations are sent from Hospital Information System (HIS) via Philips broker Xcelera or CIS to the modalities like Ultrasound and / or Cardio Vascular modalities. For Picture Archiving and Communications System (PACS) the workstation viewer product from Philips are Cath View, Echo view and View Forum. Long term 'Archive and Back-up' products are the same as mentioned in the Hospital Workflow section.

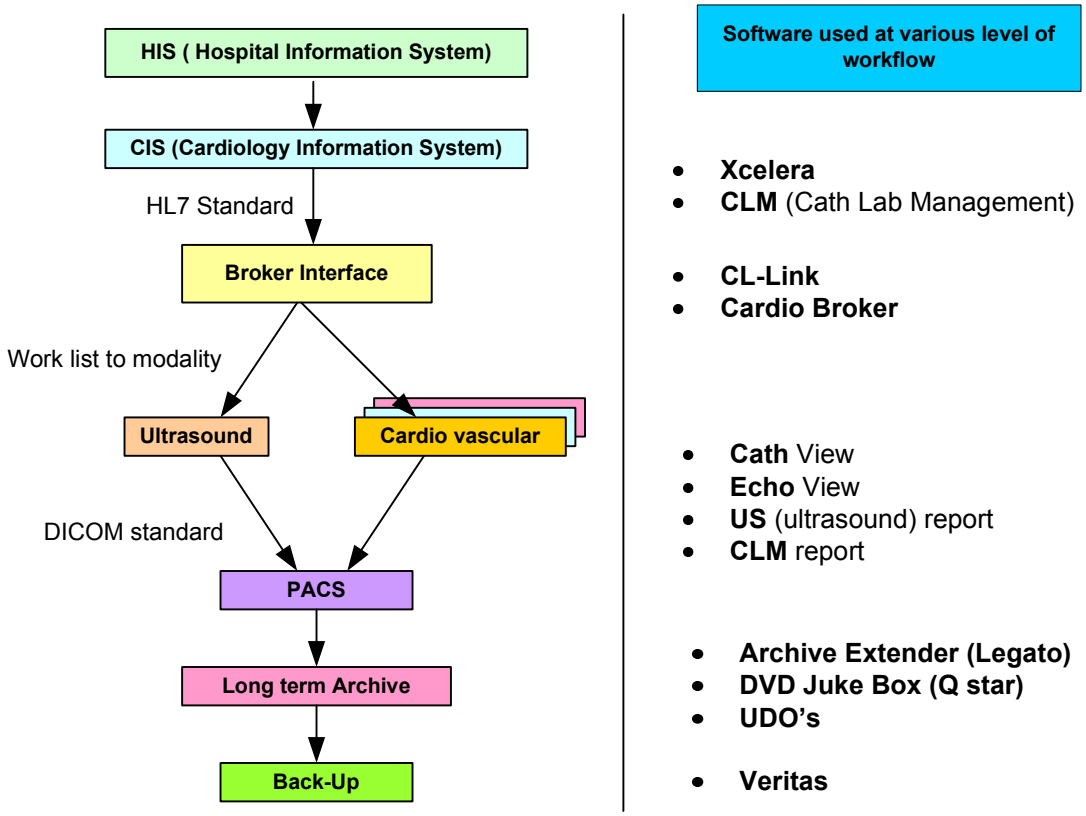

Figure 11: High Level Cardiology Information Flow

3.5 Remote Service Network

The Philips Worldwide Remote Services Network (RSN)[10] is an advanced, private network linking Philips Medical Systems equipment to their global Remote Service Centers. In order to deliver speed, reliability and advanced security, the Philips RSN leverages the customer facility's network via the Internet using secure encrypted Virtual Private Network (VPN) communication by replacing slow, unprotected and unreliable modems with router.

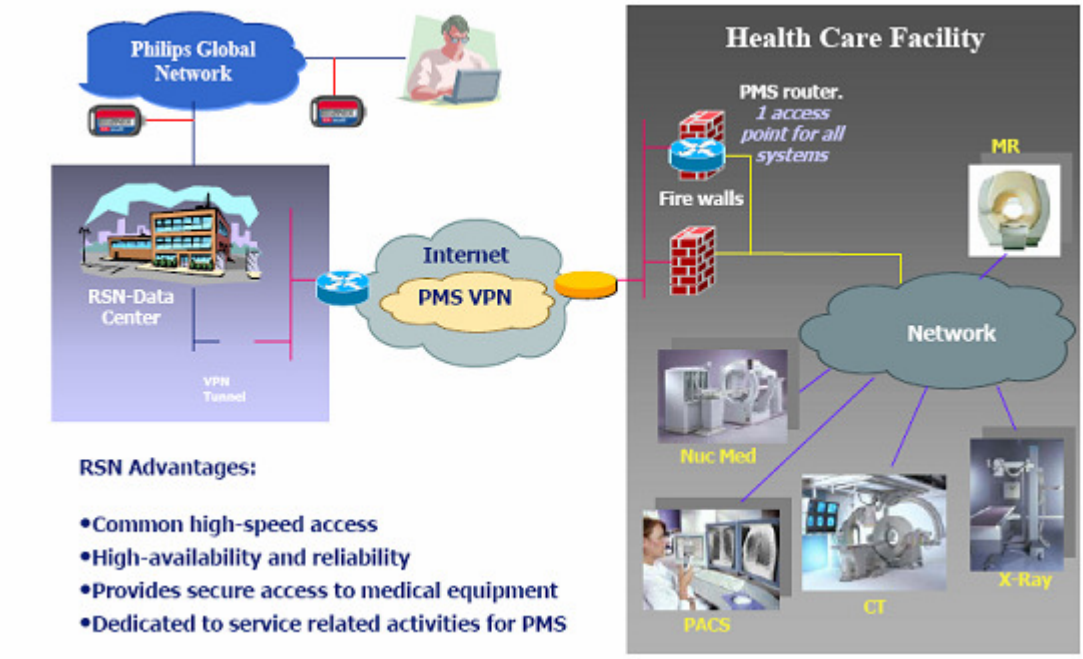

Figure 12: Remote Service Network (Source: Philips Medical Systems)

RSN proactively speeds resolution of software problems, applications issues, and performance concerns. System data is analyzed to diagnose potential problems before they become real problems. It helps clinicians to share information real-time with Philips engineers – and because equipment uptime is optimized – perform at higher levels of proficiency. Image quality issues, for example, can often be resolved remotely and quickly, which is not possible with a dial-up connection.

RSN utilizes a high-speed network infrastructure, replacing slow and unreliable modems and dedicated telephone line for each connected device. This not only facilitates faster analysis and diagnosis be obtained, but also faster software downloads and upgrades. The system has no adverse effect on local network performance.

A Virtual Private Network (VPN) tunnel is established from the Philips RSN Data Center to the VPN concentrator or RSN router placed at customer site (or sites). The VPN tunnel is secured with IP sec, 3DES encryption using Internet Key Exchange shared secret keys.

Two firewalls are installed at the edge of the Philips RSN Data Center to control traffic. One

firewall isolates the RSN Data Center from the rest of the Philips Global Network. The other firewall is built into the VPN core router.

Every connected Philips system is assigned a static NAT IP and DNS address that is configured in the RSN Data Center.

4. Analysis

This chapter introduces and provides information about ITIL™ IT Service Management. The ITIL™ IT Service Management best practices approach was adopted for this project thesis. The reason behind to select the ITIL™ has been explained in section 4.2. ITIL™ best practices towards the Service Support facilitate the identification of the Configuration Items in the Healthcare IT products and solutions.

4.1 UML Approach

This section describes why the UML notation is decided to model data model. The reason for deciding the UML notation is that in the UML notations, specifically the Class diagram can represent the static data which is essential for data model. Moreover, this diagram facilitates to create, store, change and delete the data type easily. The notations are easy to use for me. Also at present this notation is widely used in IT domain.

Appendix 6 provides the basic definitions and information related to UML notation used in the conceptual data design.

4.2 ITIL Approach

This section describes argument for why the ITIL approach is decided for this thesis. The reason I decided to use ITIL definition and best practices is because it is based on British Standard (BS 15000). Moreover the ITIL IT Service Management describes the high level framework (described in section 4.3.1) of IT Service Management to in depth detail. For example, in configuration management it provides in depth information how to implement, practice and control the configuration items. Configuration items are the components such as servers, work stations, software suits, various documents like project plans, service level agreements, network details, storage disks etc,. These information and definition of the configuration items is well suited to this thesis because this project is carried out in the IT Service Support domain. The Healthcare Informatics products handles different type of servers like database server, Web server, application server etc., workstations, storage drives, RAID and tapes, router, software suits etc,.

The reason for not deciding the approach based on the definitions of CMII (Configuration Management II) by *Vincent C. Guess* (in his book CMII for Business Process Infrastructure) expands the scope of Configuration Management and emphases more on the documenting the changes etc., This approach is not selected for this thesis because the definitions are not specific to the IT Service Management. Whereas the ITIL IT Service Management's CM definitions are 100% related the IT service management and it takes care of the stakeholder such as problem management, change management, service level management, availability management and capacity management. In case of the CMII, the book describes the implementation well but again this is not 100% related to IT service management.

4.3 Introduction ITIL

This section provides a brief overview of the Information Technology Infrastructure Library™ (ITIL)[15] [7]. Since this research thesis is performed in the IT service management, vital knowledge about ITIL adds value to the research topic because the ITIL policy is based on quality systems, such as the ISO 9000 series, and the Total Quality framework, such as that of the EFQM (European Foundation for Quality Management).

4.3.1 ITIL Publication Framework

The ITIL publications each address part of the framework. This framework is shown in figure 13, which is high level business architecture of the IT Service Management. They provide:

- An outline description of what is needed to organize IT Service Management.
- A definition of the objectives, activities, inputs and outputs of each of the processes required in an IT organization.

However, ITIL does not prescribe how these activities should be implemented, as this will be different in every organization. The emphasis is on an approach that has been proven in practice, but that, depending on the circumstances, may be implemented in a number of ways. ITIL is not a method; instead it offers a framework for planning the essential processes, roles and activities, indicating the links between them and the necessary lines of communication.

ITIL is based on the need to supply high-quality services, with an emphasis on customer relationships. The IT organization will have to fulfill the agreements with the customer which means maintaining good relationships with customers and partners such as suppliers.

The ITIL publication framework, figure 13, shows the current set of ITIL best practice publications. The Service Management processes, at the center of the ITIL framework, are divided into the two core areas, i.e. Support and Delivery.

[15] ITIL is a registered trademark of CCTA (Central Computer and Telecommunications Agency) now Office of Government Commerce, OGC (British Government)

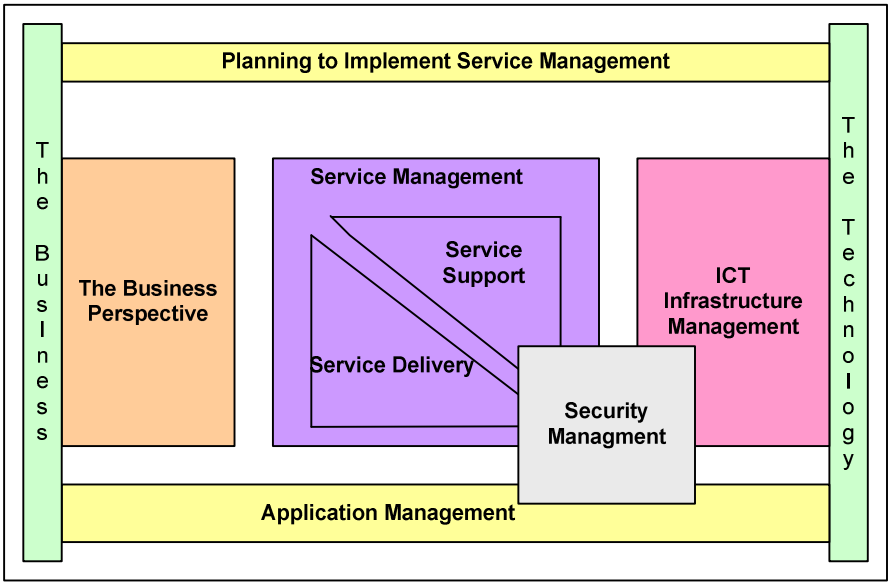

Figure 13: The ITIL Publication Framework (Source: [7])

As indicated in the figure above, Service support and Service Delivery are considered to be at the heart of the ITIL framework for IT service Management. The following subjects are addressed in the Service Delivery:

- Service Level Management
- Financial Management for IT services
- Capacity Management
- IT Service Continuity Management
- Availability Management

Service Support describes how customers and users can get access to the appropriate services to support their activities and the business, and how those services are supported.

The following subjects are addressed in the Service Support:

- Service Desk
- Incident Management
- Problem Management
- Configuration Management
- Change Management
- Release Management

Following are some definitions of subjects in Service Support; this is to acquire better insight towards understanding next section 4.1.2:

- **Service Desk [7]**: The Service Desk is the initial point of contact with the IT organization for users. A Service Desk can have a broader role (for example receiving Requests For Change – RFC's) and it can carry out activities belonging to several processes.
- **Incident Management [7]**: Incident Management is a reactive task, i.e. reducing or eliminating the effects of actual or potential disturbances in IT services, thus ensuring that users can get back to work as soon as possible. For this reason, incidents are recorded, classified and allocated to appropriate specialists; incident progress is monitored; and incidents are resolved and subsequently closed. (**Incident [7]** – *Any event which is not part of the standard operation of a service and which causes, or may cause, an interruption to, or a reduction in the quality of that service*)
- **Configuration Management[7]**: Configuration Management addresses the control of a changing IT infrastructure[16] (standardization and status monitoring); identifying all significant components within the infrastructure; collecting, recording and managing details about the components; and providing information about them to all other processes.

4.4 Identifying Configuration Items (CI's)

The objective, scope and priorities of Installed Base and Configuration Management have to be defined within Service Management and should be aligned with the business objectives. Identification is related to defining and maintaining naming conventions and version numbers of physical components of the IT infrastructure along with documenting the relationship between them and their relevant attributes.

The general question [based on ITIL] about the identification of IT components is:

> *'What services and associated IT infrastructure components should be controlled by Service Management disciplines and what information do we need for that?'*

When identifying the Configuration Items (CI's), care must be taken about the scope and level of detail of the information that is recorded. An owner or stakeholder has to be identified in each of the CI's, and the attributes derived from them recorded. At this time it is important to note that if more attributes of configuration items are recorded, the effort taken to update the information will also be greater. The general question mentioned above can be detailed to determine the information to be recorded. Following questions helps in finding the resources needed to carry out the process of registration and identifying Configuration Items as well as its attributes; (the answers for these questions follow this section)

a. What resources are available for collecting the information?
b. What resources are available for updating the information? (This will be covered in the

[16] Infrastructure (in this document) would include the application, operating system, database management system (DBMS), communications protocols, compilers and other development tools

Recommendation Chapter 7)

c. How mature are the administrative and logistics processes?
d. Which Configuration Items will impact the services if they are affected by a fault?
e. What kind of information is relevant when diagnosing such faults?
f. Which data should have their status and status history recorded?
g. Which attributes or components are used in several versions or variants?
h. Which components may affect the capacity and availability of the services after a change?
i. What are the current and future information needs of the other processes?
j. Which components should have information such as the serial number, purchase date, and supplier?
k. What requirements are associated with the provision of the Service Level Agreement?
l. Which information is necessary for billing purposes?

Answers to these questions provide information to build the data model.

4.5 Detailing Configuration Items (CI's)

Answering the questions below from the previous section provides the detailed information of the Configuration Items gathered during both the 'Analysis and Design phase'.

- What resources are available for collecting the information?
  During the analysis phase various documents were carefully read, examined and interpreted. (An overview of the list of documents can be found in Appendix -2.)

- How mature are the administrative and logistics processes?
  Philips Medical System's administration and logistics processes are well defined and controlled. An overview of the list of documents procedure is listed in Appendix -2.

- Which Configuration Items (CI's) will impact the services if they are developing a fault?
  Configuration Items types which will impact the services if they are faulty ,are the server, workstation, software suite, HL7 and DICOM protocol configuration, storage components (like Tapes, RAID-Redundant Array of Independent Disk, DVDs) and support items (like UPS, monitors, figure print keyboards)

- What information is relevant when diagnosing such faults?
  The Information that is relevant for diagnosing faults, categorized in Configuration Items is captured as attributes (level of detail) in the data model. These attributes determine the information available about individual CI's and the names.

- Which data should have their status and status history record?
  Any Information that is known to have a history of record for a CI's and / or attributes status is taken care of in 'Conceptual Data Design'.

- Which attributes /components are used in several version or variants?
  CI's such as the software suite, server(s), workstation(s) and storage(s) are the components used in several version or variants.

- Which components may affect the capacity and availability of the services after a change?
  CI's such as the software suite, server, workstation and storage are the components that may affect the capacity and availability of the services after a change.

- Which components should have information such as the serial number, purchase date, and supplier available?
  CI's such as software suite, server, workstation, storage and support items are the components that should have the information.

- What requirements are associated with the provision of the Service Level Agreement?
  The two main requirements associated with the provision of the Service Level Agreement are attributes 'WarrantyEndDate' and 'MaintenanceEndDate', which are included in the 'Conceptual Data Design'.

- Which information is necessary for billing purposes?
  Information necessary for charging purposes are covered in the contract details and not covered in the scope of this thesis. For example, this information can be upgrading the hardware configuration, software configuration (which are not covered in Service Level Agreement), service charges etc.

5. Design

This chapter is the core for the thesis design and describes the design phase. Since the project is related to IT domain the release management in this domain is explained. Some information is provided to gain knowledge about the stake holders both in ECCC group and in CC group. Process flows explain these stake holders. Then the "Conceptual Data Design" is explained in detail. Finally, the conclusion provides improvement in the ECCC process flow when the design is implemented. It also includes some important notes related to Remote Service Network.

5.1 Release Management – Information Technology

This section provides the basic information to specify release management in the IT scenario. This will in turn help to understand the *'Conceptual Data Design'*.

Release Management [7] aims to ensure the quality of the production environment by using formal procedures and checks when implementing new versions. Release Management is concerned with implementation, unlike Change Management, which is concerned with the complete change process and focuses on risk. Release Management works closely with Configuration Management and Change Management to ensure that the common Configuration Management database is updated with every release. Release Management also ensures that the contents of releases are updated in the Library (if maintained). Configuration Management also keeps track of hardware specifications, installation instructions, and network configurations. However, in general, Release Management is primarily concerned with software.

5.1.1 Basic Concepts – Philips PMG (Product Management Group)

In general the Philips Product Management Group (PMG) [8] uses the following software identifications (taken from QA manual [8]):

- **Release**: Major new functionality (can be product generation break, even backwards compatible with installed hardware/ operating system)
- **Sub-Release**: Minor new functionality (compatible with previous installed hardware/ operating system)
- **Level**: Major bug repair and Minor new functionality, replacing the full software product
- **Service Pack**: Bug repair, on-top of software product installation accumulates all changes, and is meant for world-wide distribution.
- **Hotfix**: Bug repair, meant to solve a specific problem, distributed only to specific customers.

For problems in the field, the general purpose is to have bug repairs in the shortest time possible, available in a fast but controlled manner. For this, Service Packs and Hotfixes are used. The choice between a Service Pack and Hotfix is determined by the scope or impact of the bug repair to customer(s). Also, in the decision other aspects are included. For example, a Service Pack requires more extensive validation and / or verification work, thus longer throughput time than

Hotfixes.

A Hotfix is made to quickly solve a specific problem and is distributed via the Helpdesk to the site(s) that need it. Officially it is not cumulative, and is meant for specific customers only. A Service Pack is officially released world-wide, and accumulates all repairs. A Service Pack is published centrally for download, while a Hotfix is not.

5.1.2 Basic Concepts - ITIL ™

This section provides basic concepts described by ITTL™. Since some software are supplied by external vendors, it is worth knowing the basic concepts behind Release Management in general.

Releases:
Releases comprise one or more authorized changes. The first subdivision is based on the release level. Releases are often divided into:

- **Major releases [7]** – major rollout of new hardware and software, generally with significantly increased functionality. These releases often eliminate a number of known errors, including workarounds and temporary fixes.
- **Minor software release and hardware upgrades** [7] – these generally include a number of minor improvements and fixes of known errors. Some may have been implemented as emergency fixes earlier but are now comprehensively dealt with in the release. Such a release also ensures that the 'Previous Trusted State', the starting point for all tests, is updated.
- **Emergency fixes [7]** – normally implemented as a temporary fix for a problem or known error.

If several releases are available, they are given unique identifiers. The release identification should refer to the relevant CI (configuration item) and include a version number of two or more digits, for example:

- **Major releases:** v.1, v.2, v.3, etc.
- **Minor releases**: v.1.1, v.1.2, v1.3, etc.
- **Emergency fix releases**: v.1.1.1, v.1.1.2, v.1.1.3

5.2 CI Relationships and Attributes

The relationships between CI's are useful for diagnosing errors and predicting the availability of services, for which many different logical and physical relationships are to be recorded.

- **Physical relationships**
  - *Forms part of*: this is the parent / child relationship (refer figure 14) of the CI, e.g. a disk drive forms part of a Personal Computer, and a software module

forms part of a program.
- *Is connected to*: e.g. a PC is connected to LAN (Local Area Network) segment
- *Is needed for*: e.g. hardware needed to run an application.

➢ **Logical relationships**
- *Is a copy of*: e.g. copy of a program
- *Related to*: a procedure, manual, documentation, and Service Level Agreement.
- *Is used by*: e.g. a CI needed for providing a service, or a software module which is called by a number of programs.

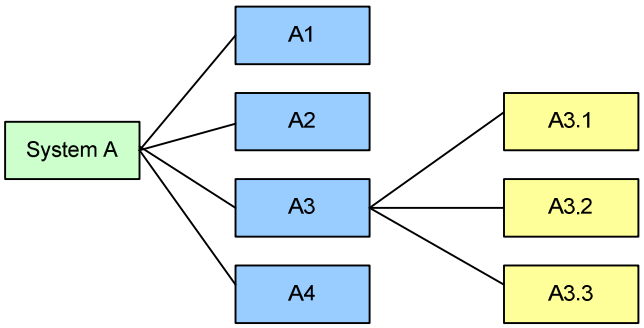

Figure 14: CI parent / child relationship (source: [7])

For each CI type the detailed development of its attributes and relationships are defined. Attributes are used to store information relevant to the CI type. These attributes are defined in section 5.4.

5.3 Stakeholders Flow chart

This section provides a flow chart, which briefs the stakeholders about the following:

(a). Purchase, Logistics, Solution Preparation and Shipment from Competence Center group and
(b). Service Delivery – Healthcare IT group

5.3.1 Purchase, Logistics, Solution Preparation and Shipment – CC Group

The figure shown below (refer appendix 11.7 for basic information) is an extract of four different manual procedures, well defined in the CC group, namely:

- MIT Project Organization and Planning
- HIT Solution Preparation (ITF)
- MIT Purchase and Logistics and Maintenance
- MIT Competence Center Service Delivery

followed by the Competence Center (CC) group. The four process flow procedures are simplified to explain the different processes to the stakeholders.

Process flow-Purchase, Logistics, Solution Preparation & Shipment – CC Group

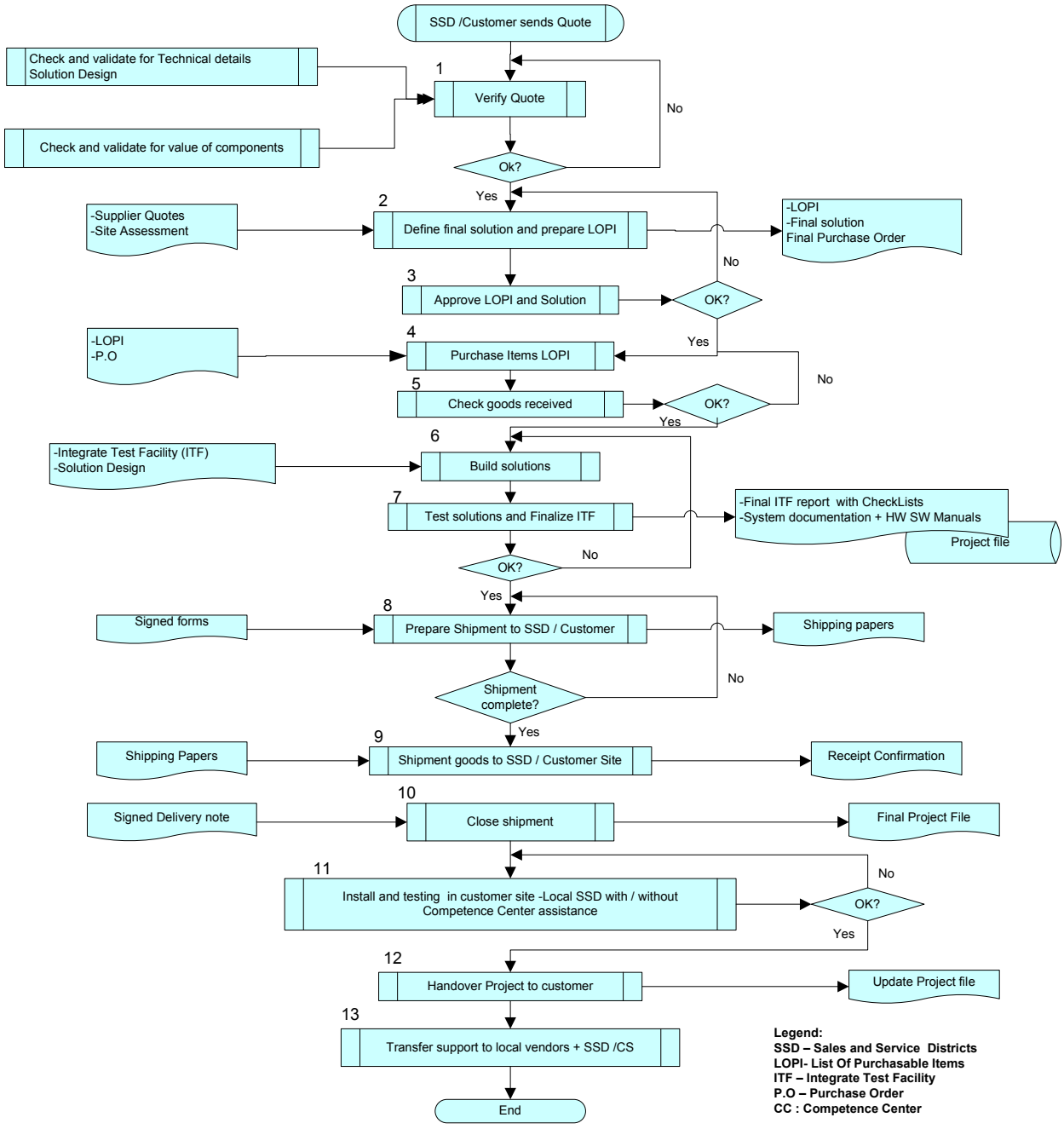

Figure 15: Process Flow- Purchase, Logistics, Solution Preparation and Shipment – CC Group

Step 1
A quote is received from Sales Service Districts (SSD)/ Customer. The quote from the SSD / customer is verified in Competence Center (CC). Technical Consultants and Application Consultants then validate technical requirements. Back-office Officer validates with regard to the value of the components mentioned in the quote. If 'OK', proceed to step 2; otherwise communicate to SSD/ Customer and correct.

Step 2
The Technical Consultant defines the final solution according to the actual workflow analysis and site information.
The Technical Consultant and Back-office Officer prepare the List Of Purchasable Items (LOPI) from the final Solution design and quote information.

Step 3
The CC Team Leader and Technical Consultant agree on the LOPI and if agreed (content and financial), the CC Team Leader approves the LOPI. If 'OK' proceed to step 4, otherwise proceed to step2 and correct/ adapt the LOPI.

Step 4
Back-office purchases items.

Step 5
The Technical Consultant checks the received items according to the LOPI. If OK, proceed to step 6, otherwise report deviations to the Back-office Officer who will claim the supplier.

Step 6
The Technical Consultant builds the solution according to the information that is provided like Solution Design, Integrate Test Facility (ITF) Etc. and performs the test according test plan. The Technical Consultant regularly updates the CC Team Leader and Project Officer on the progress made. An ITF document will be created with all test results and signed by the Technical Consultant. In cases where the ITF are finalized at the customer's site, the ITF report will be drafted after shipment, installation and complete configuration and testing at the customer. This is in order to enable to put all relevant configuration and test data in the report.

Step 7
After the ITF has been completed successfully, the Technical Consultant and the Back-office Officer finalize all the required system documentation and collect all Hardware / Software manuals (CD-ROM's) which are delivered together with the systems. The ITF document and the system documents are added to the project file.

Step 8
The Technical Consultant and the Back-office Officer organize the shipment, including all system documentation, CD-ROM etc. The Back-office arranges shipment to the customer. If the

shipment is complete, proceed to step 9, otherwise proceed to step 7 and report to Back-office Officer.

Step 9
The receipt of the material for the SSD is done (by internal procedure defined). The Back-office Officer receives the receipt confirmation from the SSD Project Officer.

Step 10
The Back-office Officer checks for the receipt confirmation in cooperation with the Project Officer.

Step 11
Final check, install and testing is done at the Customer site by local SSD with or without Technical Consultant and Integration Consultant.

Step 12 and 13
The Back-office Officer in cooperation with the Technical Consultant arranges on the handover of the Hardware / Software maintenance to the local vendors and the SSD. The Back-office Officer updates the Project form.

5.3.2 Service Delivery – Healthcare IT Group

Figure 16, shown below (refer appendix 11.7 for basic information) explains 'Service Call Handling Flow for External Customers' by the ECCC group. The process steps 2, 5, 10, 11 and 12 require the Installed Base details for the service call support activities.

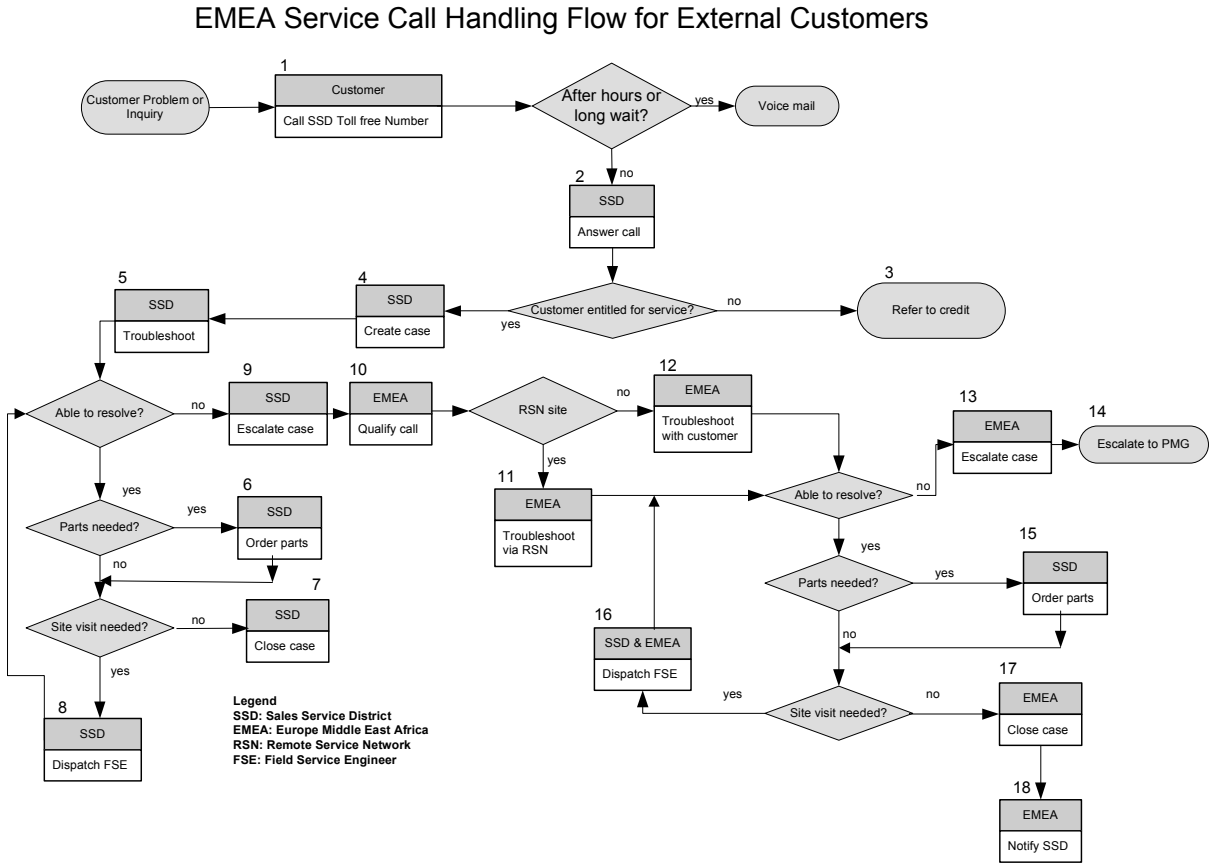

Figure 16: Service Call Handling Flow for External Customers – ECCC group -At present (Source: Philips Medical Systems)

5.4 Installed Base and Configuration Management Design

This section provides the core design for an Installed Base and Configuration Management (from now on referred to as 'Conceptual Data Design') for the Healthcare IT Product Family that includes mainly Hardware and Software components.

Every IT organization has information about its IT infrastructure[17]. Such information is particularly likely to be available after major projects. However, the challenge is in keeping the information up-to-date. Configuration Management System [7] aims to provide reliable and up-to-date details about the installed base. Most importantly, these details include not just details on specific items in the infrastructure (Configuration Items, or CI's), but how these CI's relate to one another. These relationships form the basis for impact assessment. The 'Conceptual Data

[17] Infrastructure (in this document) would include the operating system, database management system (DBMS), communications protocols, compilers and other development tools

Design' covers these relationships (as defined by ITIL™ [7]).

Just to refresh the definition of CI (as defined by ITIL [7]) before continuing with design explanation:

> ***Configuration Items (CI's)***
> ***In the terminology of Configuration Management, IT components and the services provided with them are known as Configuration Items (CI's). CI's can include PC hardware, all kinds of software, active and passive network components, servers, central processors, documentation, procedures, services and all other IT components to be controlled by the IT organisation.***

Figure 17 show the Configuration Items (CI's) of Healthcare IT product family. CI's of Healthcare IT products and solutions are Database server, Application Server, Web Server, Server, Backup Server, Router, Workstation, Tape Drive, Remote Service Network, Management PC, Monitor, RAID (Redundancy Array of Independent Disk)[18], Software suite and documentation related to service in Installed Base and Configuration Management.

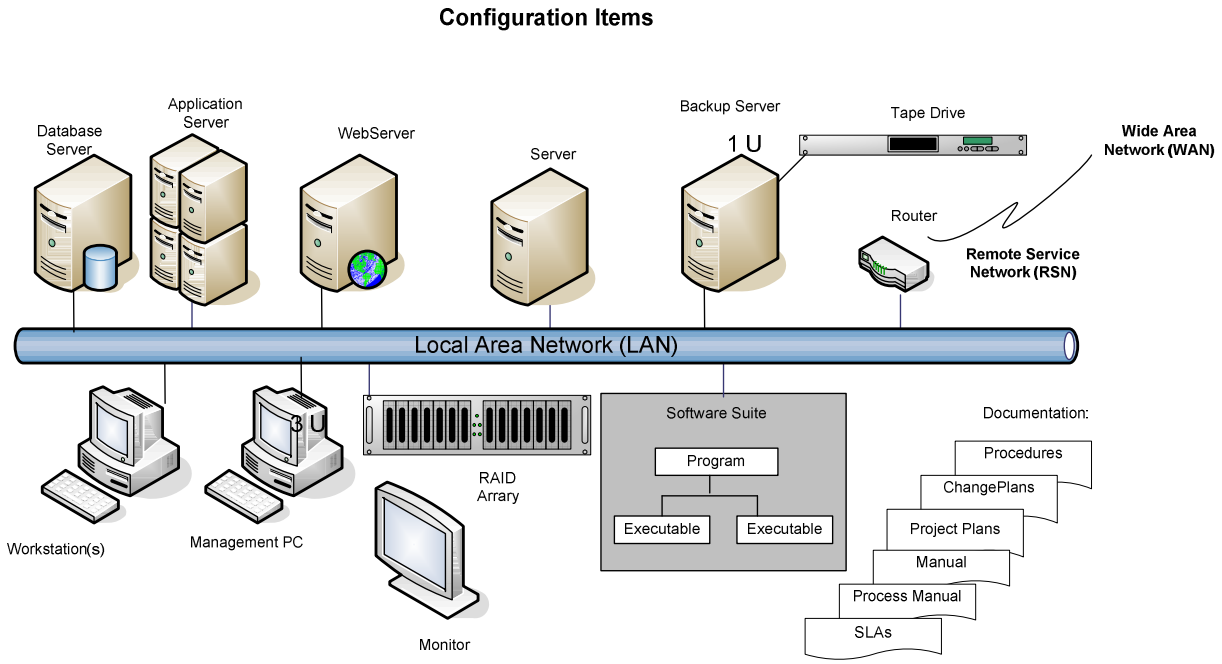

Figure 17: Configuration Items (CI's)

[18] RAID (Redundancy Array or Independent Disk): It is a category of disks that employ 2 or more drives in combination for fault tolerance and performance.

5.4.1 Conceptual Data Design

This section details the conceptual data design related to CI's and their interrelations. The conceptual data design is in Unified modeling language – Class diagram (refer appendix 11.6, for basic information).

Figure 18 shows the Conceptual Data Design. Explanation of the Conceptual Data Design and its attributes with their relationships, are defined for each CI. Attributes specify what information on the CI type must be stored in the system. In figure below, the class 'Customer' has one to many relationships with 'HIT Product Install', which means one customer, may have many 'HIT Product Install'. Another example is class 'SW HW Product' has one to many relationships with 'SW Release', which means one 'SW HW Product' has many 'SW Release'. The same type of reading applies to all other relationships except, the multiplicity may differ in other cases.

In a class diagram, there are three instances where the generalization – specialization, inheritance are used. For instance,

- 'HIT Part' is a generalized object class who's properties then are inherited by the more specific 'HW Part Install' class and 'SW Part Install' class.
- 'SW Release' is inherited to more specific classes like 'SW Version', 'SW Level', 'Service Pack' and 'SW Hotfix'.
- 'HW Part Install' is inherited to more specific classes like 'Server', 'WorkStation', 'Storage', and 'Support Item'.

The following tables provide information in detail for the attributes of each class corresponding to the 'Class Name'. This explains the setting up infrastructure CI's in an Installed Base and Configuration Management.

Class Name: Customer	
Attributes	**Description**
Customer Name	Name of the Customer to whom the product is installed
Invoice Address	Address of the organization invoiced
Ship to Address	Address where the goods shipped to
Region	Region name where the product installed
Customer Contact Person Name	Name of the person to contact at Customer location
Customer Contact Person Phone No.	Phone number of the contact person at Customer Location

Table 1: Class Name: Customer

Class Name: HIT Product Family	
Attributes	**Description**
Name	Name of the Product type
Description	Description if any

Table 2: Class Name: HIT Product Family

Class Name: SW HW Product	
Attributes	**Description**
Product Name	Name of the Product
Quantity	Quantity of the product

Table 3: Class Name: SW HW Product

Class Name: HIT Product Installation	
Attributes	**Description**
SAP Project Number	Project Number created in SAP for specific Customer Purchase Order
Project Status	Project status at any given time after Project is initiated
Installed Address	Address where the product is Installed
Installed Date	Date of product Installed
Customer Project Acceptance Date	Date on which Customer accepts the installed project (Products).
Project Handover To Service Date	Date on which the project is handover to the ECCC Healthcare IT group for support activities.
SSD Distributor Contact Person Name	Contact Person Name from SSD or Distributor's.
SSD Distributor Contact Phone Number	Contact Phone Number of SSD or Distributor's.
SSD Distributor Contact email ID	Email ID of contact person from SSD or Distributor's.
Warranty End Date	Warranty end date

Table 4: Class Name: HIT Product Installation

Class Name: Integrate Test Facility	
Attributes	**Description**
Document Name	Document name of Integrate Test Facility
Document Number	Document Number of Integrate Test Facility
Document Date	Document date of Integrate Test Facility
Document Status	Status of the document
Check List Name	Check List Name found in Integrate Test Facility document.

Table 5: Class Name: Integrate Test Facility

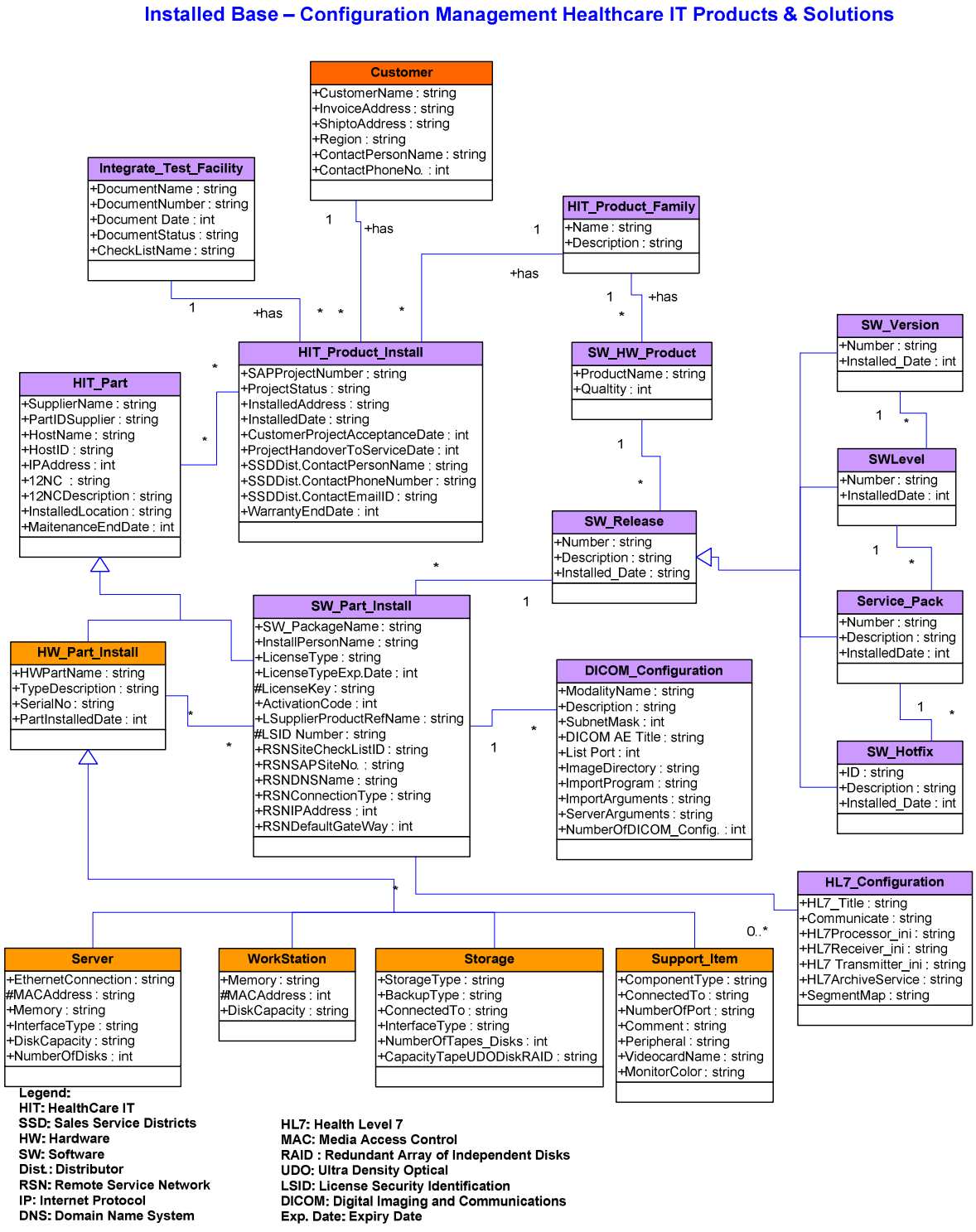

Figure 18: Conceptual Data Design

Class Name: HIT Part	
Attributes	**Description**
Supplier Name	Supplier who supplies the part
Part ID Supplier	Part Identification by the supplier
Host[19] Name[20]	Unique name of the Server / Computer
Host ID	Unique ID of the Server / Computer
I.P address	I.P address of the system (server / computer) on which the software package is installed.
12 NC	12 digit number by Philips
12 NC Description	12 NC number's description
Installed Location	Parts installed location
Maintenance End Date	Part's maintenance end date

Table 6: Class Name: HIT Part

Class Name: SW Part Install	
Attributes	**Description**
SW Package Name	Name of the software package installed
Install Person Name	Name of the person who installed the software package
License Type	Type of the License: whether it is temporary or permanent
License Type Exp. Date	Type of the license expiry date
License Key	Key for the license provided by the software package supplier, if any.
Activation Code	Activation code for the software package provided by the supplier, if any.
L Supplier Product Ref Name	Product reference name of the software package license provided by the supplier, if any.
L SID[21] Number	Security Identification number used for License
RSN Connection Type	Name of the Type of the connection in RSN
RSN DNS Name	DNS Name in RSN
RSN SAP Site No.	SAP Reference Number
RSN Site Check List ID	Unique ID recognized by RSN (It is site ID)
RSN IP Address	RSN's IP address
RSN Default Gateway	Default gate way connection by RSN

Table 7: Class Name: SW Part Install

[19] Host (server):A computer that provides client stations with access to files and printers, a shared resources to a computer network.

[20] Host Name is the unique name of a machine. When the host operating system is set up it is given a name. This name may reflect the prime use of the machine.

[21] In Windows operating systems, the security identifier (SID) is a unique alphanumeric character string that identifies each operating system and each user in a network of windows environment.

Class Name: SW Release	
Attributes	**Description**
Number	Release number which comes with the software package.
Description	Description for the release, if any.
Installed Date	Installed date of release

Table 8: Class Name: SW Release

Class Name: SW Version	
Attributes	**Description**
Number	Version number which comes with the software package.
Installed Date	Installed date of version.

Table 9: Class Name: SW Version

Class Name: SW Level	
Attributes	**Description**
Number	Level number which comes with the software package.
Installed Date	Installed date of Level.

Table 10: Class Name: SW Level

Class Name: Service Pack	
Attributes	**Description**
Number	Service Pack number for the software package.
Description	Description for the service pack, if any.
Installed Date	Installed date of service pack

Table 11: Class Name: Service Pack

Class Name: SW Hot Fix	
Attributes	**Description**
ID	Hot fix release / solution ID for the software package.
Description	Description for the Hot fix, if any.
Installed Date	Installed date of Hot fix.

Table 12: Class Name: SW Hot Fix

Class Name: DICOM configuration[22]	
Attributes	**Description**
Modality Name	Name of the Modality connected to
Description	Description if any
Subnet Mask	Sub net mask number
DICOM AE Title	Unique title given for DICOM configuration
List Port	List port configuration (an integer)
Image Directory	Path name of the Images stored in directory
Import Program	Import program configuration
Import Arguments	Import Arguments configuration
Server Arguments	Server Arguments configuration
Number of DICOM Configuration	Total number of DICOM configuration installed in installed location.

Table 13: **Class Name: DICOM configuration**

Class Name: HL7 Configuration[23]	
Attributes	**Description**
HL7 Title	Title of the HL7
Communicate	Name of the information system protocol configured to and communicated to. It can be either HIS or RIS.
HL7Processor_ini	HL7Processor_ini configuration file.
HL7Receiver_ini	HL7Receiver_ini configuration file.
HL7Transmitter_ini	HL7Transmitter_ini configuration file.
HL7 Archive Service	HL7 Archive Service configuration file.
Segment Map	Segment Map configuration file.

Table 14: Class Name: HL7 Configuration

Class Name: HW Part	
Attributes	**Description**
HW Part Name	Name of the hardware part (for example, server / workstation name)
Type Description	Type description of hardware part, if any.
Serial Number	Unique traceable serial number of hardware part
Part Installed date	Installed date of part (includes the replaced and / or upgraded date).

Table 15: Class Name: HW Part

[22] DICOM configuration : Digital Imaging and Communications in Medicine's Protocol configuration

[23] HL7 configuration : Health Level Seven - Protocol configuration

Class Name: Server	
Attributes	**Description**
Ethernet Connection[24]	Configuration of Ethernet connection whether the connection speed is 10mbps (mega bits per second) or 100 mbps or 1000mbps.
MAC Address[25]	Unique ID of server's MAC (Media Access Control) address.
Memory	Internal memory of the server
Interface type	Normally it is two type of storage, SCSI (for backup) and / or Fiber (mainly for archive and / or working storage)
Disk Capacity	Capacity of disk available in the server
Number of Disks	Number of disks available in the server

Table 16: **Class Name: Server**

Class Name: Workstation	
Attributes	**Description**
Memory	Internal memory of workstation
MAC address	Unique ID of Workstation MAC address
Drive Capacity	Capacity of workstation's drive

Table 17: Class Name: Workstation

Class Name: Storage	
Attributes	**Description**
Storage Type	Name of the storage type
Backup Type	Name of the backup type
Connected to	Name of the host to which the storage / backup connected to
Interface type	Name of the interface connected
Number of Tapes Disks	Total number of tapes or disks installed
Capacity Tape Disk RAID	Capacity of Tape or Disk or RAID (Redundant Array of Independent Disks)

Table 18: Class Name: Storage

[24] A high speed direct connection to a network where an Ethernet network interface card (NIC) is installed so that the user can access any host connected to the network.

[25] A MAC address, short for Media Access Control address, is a unique code assigned to most forms of networking hardware. The address is permanently assigned to the hardware.

Class Name: Support Item	
Attributes	**Description**
Component Type	Type of the component of support item (e.g. UPS)
Support Connected to	Support item to which it is connected to, if any.
Number of Port	Number of ports support item connected to, if any.
Comment	Comments, if any.
Peripheral	Name of the peripherals attached to workstation (e.g., finger print keyboard)
Video card Name	Name of the video card
Monitor Color	Whether the monitor is in color or not

Table 19: **Class Name: Support Item**

Thus the above tables explain about the attributes in detail. The design itself explains the interrelations between the classes.

5.5 Design Conclusion

Design attributes are investigated for their crucial role in the replacement, upgrade and service call management scenario and the inflow of data from the various levels of workflow. For instance;

- Hardware plays a role in the replacement scenario.
- Hardware and software play a role in the upgrade scenario
- Both hardware and software play a role in the service call management scenario.

Note that this is deliverable D3. This file is delivered as a separate file, and it is named as "Attributes_Replacement_Upgrade_ServiceCallManagement.xls".
An illustration is projected for the above mentioned scenarios with attributes in an excel spread sheet. For example: Table 20 represents all attributes in the 'Conceptual Data Design'.

	Replacement	Upgrade	Service Call Management	In flow of data's from Work flow
SupplierName	y	y	y	3
Part_ID_Supplier	y	y	y	3
Installed_Location	y	y	y	11
12NC	y	y	y	7
Description	y	y	y	7
Warranty_End_Date	y	y	y	13

Table 20: Replacement, Upgrade, Service Call management and Data flow from Workflow

It presents the above mentioned scenario (note that the table shows only a few examples from the file "Attributes_Replacement_Upgrade_ServiceCallManagement.xls"). For instance, the above table shows that for the attribute 'SupplierName';

- replacement scenario is essential
- upgrade scenario is essential
- service call management scenario is essential
- this data originated in the 3rd block of the work flow diagram show in figure 19.

In the class 'SW Part Install', two attributes namely 'User Name' and 'Password' can be added. These attributes can be protected from other classes view and restricted. They have many to many multiplicity, which means many 'User Name' can have many 'passwords'. These attributes are not added in the design because of security and /or legal issues in the Healthcare domain.

Attributes like 'Project Status', 'Customer Project Acceptance Date' and 'Project Handover to Service Date' from the class 'HIT Product Install' are included for improving the business processes.

Figure 19shows the improved version of the call handling process of EMEA. In this diagram two new steps are included which are numbered as 7 and 17. In these steps, before closing the call handling process the replaced or upgraded parts, items or software applications have to be updated in the database by SSD.
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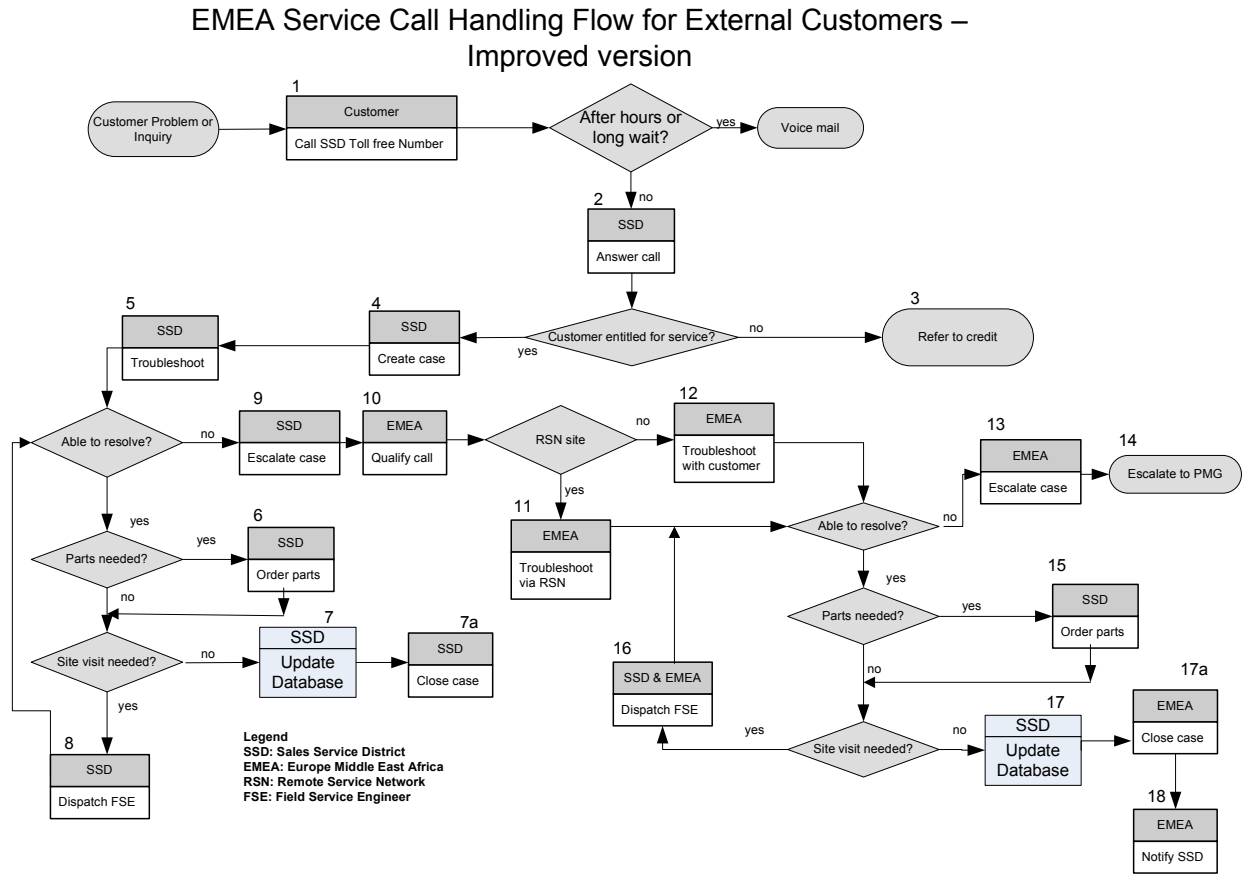

Figure 19: EMEA Call Handling Flow for External Customers – Improved version

5.5.1 Remote Service Network

In the class 'SW Part Install', there are a few attributes related to Remote Service Network (RSN) (attributes begin with 'RSN' in figure 26), these attributes are essential for Installed Base and Configuration Management. However, it has to be noted that this data is already available in the RSN database. It is enough to have only one attribute name 'RSN Site Check List ID,' which is a unique ID, traced back to part level. A few other attributes are added in the design to or highlight the important attributes related to the Configuration Management. For example, the attribute 'RSN IPAddress' this attribute has to be updated when there is an upgrade or replacement of hardware. When this attribute is not updated then it will become impossible to connect remotely to the customer's modalities (medical devices). Another example is 'RSN ConnectionType'; this gives specific information of what are the connection types applicable to connect remotely to the specific software application. There are approximately 26 different ways to connect remotely to the modality (medical device / software application). This information needs to be updated when replacing / upgrading the hardware or the software during maintenance.

6. Verification and Validation

This section describes the verification and validation of the developed Conceptual data model.

The data model is verified by developing a prototype database with some real data. The result file is delivered in the Microsoft Access and the name is "PrototypeDatabase.mdb".

The Conceptual Data Design (figure 18), Radiology Information System Hardware – Software Inheritance (figure 20) , Cardiology Information System Hardware - Software Inheritance (figure 21), PACS Information System Hardware - Software Inheritance (figure 21), Work flow Purchase, Logistics, Solution, Preparation and Shipment – CC group (figure 15) and EMEA Service Call Handling Flow for External Customers (figure 16) have been validated. These designs, workflows, and illustrations are verified with structured appointments with the Director, Technology Officer, Back-office Manager, Team Leader – CC group, Technical Consultants, Application Consultants, Technical Support Specialists, Consultant Installed-base - CS Business Process Management SSR EMEA and Remote Service Network specialists, which includes the stakeholders to validate the data model (List of Name of Officers in detail – Appendix 3).

During this phase, meeting with the various domain personnel mentioned above, have been discussed and brainstormed for each individual attributes validation. The following questions and / or points were investigated for validation of Conceptual Data Design;

- Where did the attribute initiate from?
- What does the attribute mean?
- What type of information does the attribute lead to?
- Is the type of information provided by the attribute relevant to the Installed Base?
- Is the type of information provided by the attribute relevant to the Configuration Management?
- Investigate whether the attribute are relevant to the data model or not.
- What are the types of information is essential for Installed Base and Configuration Management?
- Is the necessary information of Installed Base and Configuration Management covered in Conceptual data design?
- Who are the stakeholders?
- Scrutinize the repetitions of attributes which provide the same information.
- Inspect the interrelationships and multiplicities with classes.
- Inspect association in class diagram.
- Does the Conceptual data design show product family, product and part of hardware and software clearly?
- Does the attribute present already fit in the class?
- Are there any commonalities in the attributes that can make a class?

- Are essential attributes for a Service Call Management scenario present?

These questions help to validate the design that had many versions before evolving into the final version as seen in chapter 5. The stakeholder's inputs and corrections are carefully investigated and the data model is updated. Thus the Conceptual data design is validated for the correctness of the model with its stakeholders.

7. Recommendation for Implementation

This section describes the recommendations for implementation. The implementation of the conceptual data design is not covered by this thesis.

7.1 Tips and Tricks – Implementation

This section provides some tips and tricks during implementation of the Conceptual data design.

In the class 'SW Part Install', there are a few attributes related to Remote Service Network – RSN which begin with 'RSN' in figure 18. However, this data's is available in the RSN database. It is enough to have one attribute name 'RSN Site Check List ID'- a unique ID which can be traced back to the part level.

All data is initiated from the Competence Center group and SSD (in case SSD does the installation), in which the install details of both hardware and software part information can be traced back to the 'Integrate Test Facility (ITF)' Document. This document contains information like different types of check lists, which help to find present scenario and basic requirements to install Healthcare IT products and solutions. Apart from this, the document also contains the first installation details traceable to the hardware serial number, software release level and license. However not all ITF documents provide this information.

The following are scenarios by which the maintenance and / or upgrade details are available;

- Upgrading software for release patch or level and / or service pack, the information can be found in 'Trip Reports' made by Technical Consultants in the Competence Center.
- 'Job reports' initiated by the Support Specialist provides information regarding the maintenance details.
- Replacement or additional components or parts request from customer: It is handled by Sales Service Districts (SSD) in cooperation with the Back-office Officers. An additional sheet in the project file provides information in detail.

Information like the Project file contains List Of Purchasable Items (LOPI), all information containing financial, authorization for purchase of software and hardware parts, purchase order from customer, quotation from suppliers, etc., and master list of software packages can be found in the Back-office. Licenses are handled by Back-office Officers.

7.2 Recommendations

During the knowledge gaining phase, analysis phase and design phase, many documents and data were investigated. Following table provides information of weak areas, the current situation and recommendations to improve the Installed Base and Configuration Management of Healthcare IT products and solutions.

Weak Areas	Current situation	Recommendation
Part Identification (external suppliers)	Software part and /or hardware parts are purchased from external vendor / suppliers. Some external suppliers do not have a part ID.	For installed base and Configuration Management as defined in ITIL™, the parts need to be identified. Philips parts are identified by 12 NC numbers that have a standard and strict documentation and procedures to follow. It is recommended to initiate 12NC number for parts which are purchased from external suppliers. This leads • For a part, to get identified, which is supplied by an external vendor who is not supplied with part ID. • Unique way of numbering using standard documents and procedures to identify a part all over the Philips organization.
Hardware -Serial Number (Installed base)	Hardware parts / items cannot be traced back to serial numbers. Integrate Test Facility (ITF) document provides information of serial numbers of hardware but this does not cover all serviceable items and / or information not available for all projects.	Needless to say, the serial number is important for Configuration Management. So strict procedures should be introduced and maintained to record the serial number during installation and replacement.
Software – Traceable to Release Version / Levels/ Service Packs/ Hot fixes	Software packages cannot be traced for their release levels, which means in the installed base software packages' release levels cannot be traceable. Some Integrate Test Facility (ITF) document records information	Software packages' Release levels or service pack numbers is to be identified. So new procedures should be introduced and maintained in order to have installed base

	till release level but not all. In some cases, there was an upgrade of software; this information can be traced in 'Trip Reports' but it is very difficult to find exact information in a short time.	complete and maintain configuration management. Updating and maintaining this record will help in service call management.
Incomplete Integrate Test Facility (ITF) document	It is widely noticed that Installed Base details of Radiology Information System especially Easy RISs' ITF document is not complete (in most of the cases) and no relevant information of software or hardware details are recorded during installation.	Instructions, procedures should be introduced and maintained to record the information for Installed Base and Configuration Management.
HL7 and / or DICOM Protocol Configuration	Installed base of HL7 and DICOM is not recorded for all projects and difficult to trace these files. But few (one ITF document from Appendix2) has installed details for DICOM.	Instructions, procedures should be introduced and maintained to record the information for Installed Base and Configuration Management.

8. Conclusion

As a concluding chapter of this report, an overview of results of this research thesis presented.

This research thesis has been initiated by the ECCC group-HIT team to improve its business process for its products called "Healthcare IT Product and Solutions". It is mandatory in the healthcare products (like devices or software), to recognize essential information and maintain it. This is a legal requirement by governments worldwide.

For which, it becomes necessary to know the description of the Installed Base details delivered. This information facilitates the business and eases the Configuration Management.

At present Philips Medical Systems has standardized and controlled procedures for the Installed Base - modalities (medical devices). But this is not entirely implemented and not completely covering the HIT products specific issues. Currently, in the Competence Center group, some Installed Base information is obtainable, but this data is incomplete information. More specifically, Installed base details available for PACS information system can be considered as a good start but the information is incomplete. Still, the Easy RIS and Cardiology Information Systems have to improve greatly to cope with the requirements which are mandatory legally. Therefore, this research recognizes and explores all the technical parameters involved in the HIT products, which will improve the Configuration Management and increase business opportunities by contract and maintenance management.

This research thesis presents a conceptual data design, which is a Configuration Management System (CMS) improves the business process of ECCC – HIT team in its support activities. The design includes details to be recorded for the Installed Base Management. These details together with the technical configuration provide the CMS. The thesis describes the loop holes in the Installed Base. Specifically the installed base details recorded are incomplete in the ITF documents, which provide the installation information. The installed details are better in case of the PACS information system. The Cardiology Information System and Easy RIS installation details should be improved.

The conceptual data design can be used as a base to build a tool or implementation in SAP database. The design provides all technical details which are required for the Configuration Management. It includes the description for both the hardware and software parts of HIT products and solutions. In this hardware and software products the configuration items, as defined by ITIL® are recognized. These configuration items are investigated in-depth and the attributes are derived. These attributes provides more information about the configuration items. The design also specifies the interrelation ships of the configuration items.

This design is validated for all the HIT products and solution under Radiology Information System, Cardiology Information System and PACS. The design includes the various technical

details involved in the Remote Service Network. Specifically, one of the technical details is the IP addresses which enables to access the installed product at a customer location through the Remote Service Network. In case of hardware parts, the serviceable items with its technical details, which possibly changes during replacement and upgrade process are recognized and included in design. The possible changes in the software, due to the replacement and /or upgrade and the corresponding changes in the Remote Service Network are also covered in the design.

The attributes in the design (class diagram) are investigated for their crucial role in the replacement, upgrade and service call management scenarios. The result is delivered in the Microsoft Excel (file name is "Attributes_Replacement_Upgrade_ServiceCall Management .xls"). In the same excel sheet, the flow-in of data from various level of process flow 'figure 19' is included.

The conceptual data design is verified by developing a prototype database with some real data. The result file is delivered in the Microsoft Access and the name is "PrototypeDatabase.mdb". The conceptual data design is validated by the stake holders by the valid questionnaire.

At presently time consumed to know the configuration details at the customer location is 10%. The Configuration Management System can be profitable in reducing this time to less than 1%.

As a kick-off for implementing, the ECCC – HIT team can request for the Installed Base details based on the conceptual data design in Microsoft Access file for each project.

Recommendations, tips and tricks are provided in Chapter 7. Generally, care should be taken to

- Introduce 12NC numbers to trace hardware and software parts which are supplied by external vendors.
- Hardware parts serial is not recorded for all project and product types
- Software package release levels are not recorded for all projects and product types
- HL7 and DICOM Protocol configuration details to be recorded
- The process of recording the serial numbers (hardware and / or software) is time consuming process. So, introducing a bar code reader which can automatically read and record the serial numbers will reduce the manual recording time. This will be a good start for recording Installed Base details and be useful for the Configuration Management.

Next possible step towards implementation will be:

- Recording Installed Base of hardware and software by introducing procedures.
- Kick-off 12 NC numbers for the parts supplied by external vendors.
- Installed base details (can be a data sheet) handover to ECCC Healthcare IT group and / or to SSD to facilitate the service call management and commence the Configuration Management for the Installed project.

9. Reference:

[1] http://www.medical.philips.com/main/news/content/file_993.html
[2] http://www.philips.com/about/company/businesses/index.html
[3] http://www.medical.philips.com/main/company/aboutus/facts/
[4] http://www.medical.philips.com/main/company/aboutus/
[5] Philips Medical Systems- Customer Service Configuration Management or Physical View on Medical Systems – UXW-0306018
[6] MIT EMEA Competence Center CS EMEA power point (ppt) file – Arjon Hoeskstra –Director Competence Center.
[7] *Jan Van Bon, Mike Pieper, Annelies Van der Veen*, "IT Service Management- Based on ITIL® An Introduction"
[8] Mail from *Ben Gorissen* – Program Manager Radiology IT – Subject – Easy RIS terminology explanation, dated on 09th July 2005.
[9] *Eriksson Penker*, UML Toolkit
[10] *Philips Medical Systems'- RSN product catalogue*
[11] http://www.icmhq.com/.
[12] *Vincent C. Guess*, "CMII for Business Process Infrastructure"
[13] *Eelco A. van Veen* "Modelling Product Structures by Generic Bills-of-Materials"

10. List of Figures

10.1 List of Tables

11. Appendices

11.1 Appendix 1 – Abbreviations

Abbreviation	Expansion
CC	Competence Center
CI	Configuration Item
CIS	Cardiology Information System
CLM	Cath Lab Management
CT	Computed Tomography
DICOM	Digital Imaging and Communications in Medicine
ECCC	EMEA Customer Care Center
EMEA	Europe Middle East and Africa
HIS	Hospital Information System
HIT	Health Care IT
IBSCM	Install Base and Software Configuration Management
ITF	Integrate Test Facility
ITIL™	Information Technology Infrastructure Library™
MR	Magnetic Resonance
MRI	Magnetic Resonance Imaging
NM	Nuclear Medicine
PACS	Picture Archiving and Communication Systems
PET	Positron Emission Tomography
PM	Patient Monitoring
PMG	Product Management Group
RAID	Redundancy Array of Independent Disk
RIS	Radiology Information System
RSN	Remote Service Network
UDO	Ultra Density Optical
US	Ultrasound

11.2 Appendix 2 – List of Documents / Files used for Thesis design

The following is the list of documents used for designing Installed Base and Configuration Management (for all product types):

From back-office Competence Center group:

- Project Form and File : General Hospital Gibraltar – UK (Project No.: 641206.10/.20)
- List Of Purchasable Items (LOPI) : Project – Gibraltar , SAP number:641306

- Project Form and File : Centro Hospitalar de Coimbra – Portugal (Project No.: 150069.10/.20)
- List Of Purchasable Items : Project - Centro Hospitalar de Coimbra – Portugal
- Project Form and File : Bassano Upgrade – Italy (Project No.: 906174.10, date: 15th June 2004
- List Of Purchasable Items: Project Bassano
- Project Form and File: Nelson Mandela – South Africa (Project No.: 546368)
- List Of Purchasable Items: Project Umtala , SAP number 546368
- Project Form and File: Yeditepe University Istanbul, Turkey. Project No. 10064598.10/.20.
- List Of Purchasable Items: Project – Yeditepe , Turkey., SAP No. 1064598.10
- Project Form and File: Hospital de Madrid –Spain SP9407, Project No.: 758609.10/.20/.30
- List Of Purchasable Items: Project- Hospital de Madrid, SAP No. 758609
- Project Form and File: General Universitario Gregorio Maranon – Spain, SAP No.: 1621902.10-20
- List Of Purchasable Items: General Universitario Gregorio Maranon – Spain
- Project Form and File: LPP Queen Mary's LPP – UK, Project No.: 1619986.10 for Hardware and 1619986.20 for software

From Application Consultants -Radiology Information – Competence Center group

- Site Assessment : General Hospital Gibraltar – UK (Document no: - , Date: 11th December 2003 and Document No.: XQR041-040030, date 20th February 2004)
- Trip Reports: Doc. ID: XQR041-050012 date: 21st January 2005, Doc. ID: - date: 9th November 2004 and Doc. ID XQR041-040140)
- Integrate Test Facility (ITF) document for General Hospital Gibraltar – UK (Document No. XQR041-040138, date: 16th December 2004)
- Short Project Overview: Centro Hospitalar de Coimbra – Portugal, Doc. No.: - , date 19th October 2004
- Site Assessment: Centro Hospitalar de Coimbra – Portugal Doc. No.: - , date: 07th March 2005
- Trip Reports : Centro Hospitalar de Coimbra – Portugal Doc. ID: XQR 041-050143 date:12th July 2005, Doc. ID: XQR 041-050091 date: 15th April 2005, Doc. ID: XQR 041-050119date: 15th April 2005
- Imaging Archiving Solutions: Bassano Archive Migration & Itanium Upgrade Project (Doc. ID. : XQR-041-040105_bassano_upgrade, date: 30th September 2004
- Trip Reports: Bassano, Italy (Doc. ID: XQR 041-040101 date 17th March 2006, Doc. ID: XQR 041-050014 - date : 17th March 2006, Doc. ID: XQR 041-050046 - date : 17th March 2006 and Doc. ID: XQR 041-050061 - date : 17th March

2006)
- Site Assessment: Bassano, Italy (Doc. No.: XQR- 041-050162 – date: 25th August 2005)
- Qstar Installation Trip Report: Bassano, Italy(Doc. No.: XQR- 041-050090 – date: 12th April 2005.
- Integrate Test Facility (ITF): (Xcelera / Xcelera Web forum): Greenacres hospital Port Elizabeth, South Africa. (Document No. XQR042-050004, date: 11th April 2006)
- Integrate Test Facility (ITF): (Xcelera CLM) Prince Sultan Cardiac Center, Riyadh, Saudi Arabia.
- List Of Purchasable Items: Prince Sultan Cardiac Center, Riyadh, Saudi Arabia.
- List Of Purchasable Items: Saudi Arabia Aramco Upgrade

List of Manuals used for various Logistics, Planning and Preparation for Solutions by Competence Center Group:
- MIT Project Organization & Planning: (Ref. No.XEV-050-101 version 2)
- HIT Solution Preparation(ITF): (Ref. No.XEV-050-103 version 4)
- MIT Competence Center Service Delivery: (Ref. No.XEV-050-106 version 6)
- MIT Purchase & Logistics and Maintenance: (Ref. No.XEV-050-107 version 4)

11.3 Appendix 3 – List of Names of Manager / Officer / Consultants

- Mr. Gerard Haex - Director – ECCC group
- Mr. Pieter Both – Technology Officer – ECCC group
- Mr. Gerbert Coolen – Technical Consultant - Competence Center
- Mr. Fred van Mierlo – Team Leader – Competence Center
- Mr. Pieter Mol – Back-office Manger - Competence Center
- Mr. Bas van Breugel - Technical Consultant - Competence Center
- Mr. Rohaan Pereira – Integration Consultant - Competence Center
- Mr. Nico van Schijndel – Integration Consultant - Competence Center
- Mr. Paul Meerdink – RSN/ CCC Support Consultant – ECCC group
- Mr. Coen Sanders - RSN
- Mr. Erik Visser - Installed Base / Master Date and Reporting – CS Business Process Management SSR EMEA
- Mr. Gijs van de Ven – Support Consultant - ECCC group
- Mr. Martin Soeteman - Support Consultant - ECCC group

11.4 Appendix 4 – Literature Study

This will be attached as a separate document file.

11.5 Appendix 5 – Aggregation - Inheritance / Grouping Healthcare-IT Products

This section provides information about the products grouped under three main information systems namely:

- Radiology Information System (RIS)
- Cardiology Information System (CIS) and
- Picture Archiving and Communication System (PACS)

The Healthcare IT Products and Solutions contains RIS, CIS, PACS for both RIS and CIS, Long Time Archive (LTA), Backup, Broker Interface and Modality / Machine Interface solutions.

11.5.1 Radiology Information System – Product- Aggregation -Inheritance

Figure 20 shown below describes the hardware and software inheritance of the Radiology Information System (referred to as RIS from now).

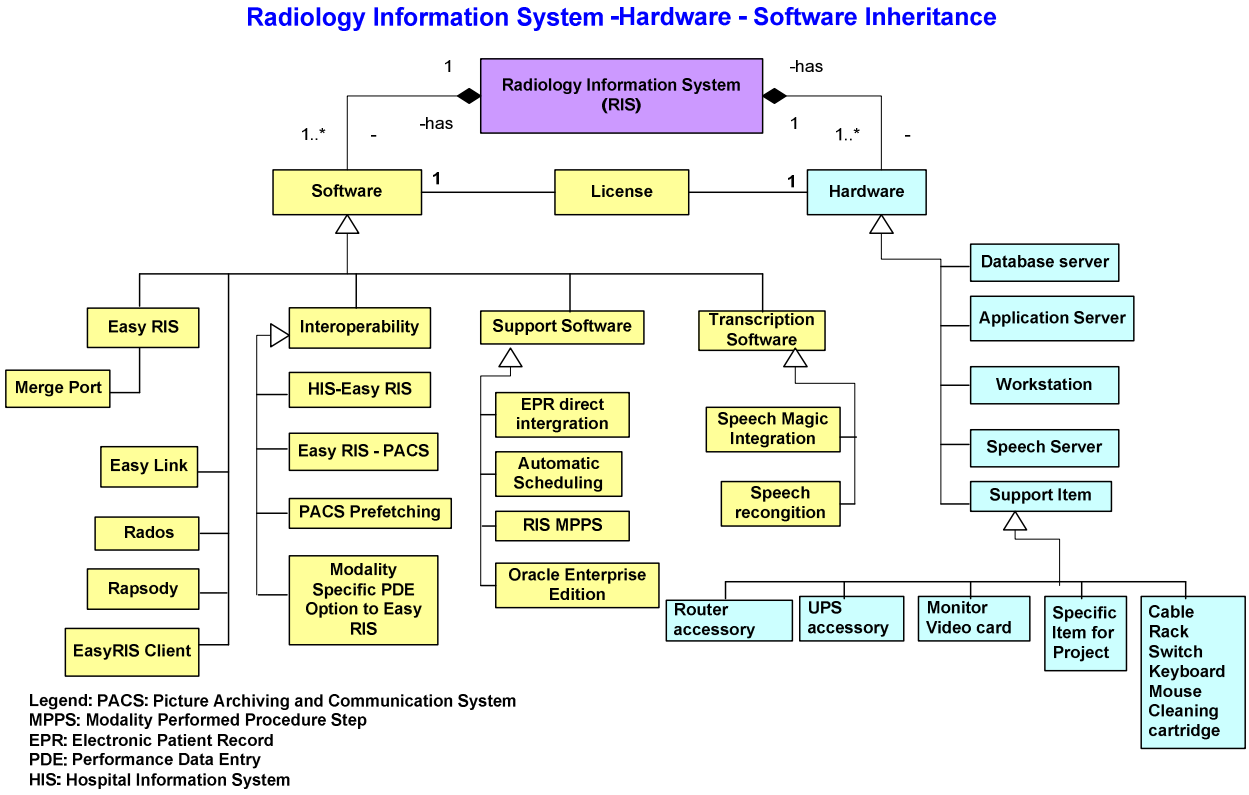

Figure 20: Radiology Information System – Software Inheritance

Radiology Information System (RIS) has composition aggregation[26] with Software and

[26] Composition aggregation is one with strong ownership.

Hardware. License has direct link to both software and hardware because it has both configurations related to them.

Software has specialization inheritance towards main objects like Easy RIS (which is a product), Interoperability (functionality), Support software suites and Transcription Software (functionality). Main specialization inheritances towards products are Easy RIS, Rados, Rapsody and Easy RIS client. Likewise, specialization inheritances for Easy RIS are Easy Link and Merge Port. Easy link is used as broker interface to connect with different RIS vendor. Merge Port is mainly used as broker interface together with Easy RIS.

Interoperability specialization inheritance consists of four main products. They are HIS (Hospital Information System) – Easy RIS, Easy RIS –PACS (Picture Archiving and Communication System), PACS Prefetching and Modality Specific PDE (Performance Data Entry) option to Easy RIS.

Support Software has specialization inheritance of four main products such as EPR (Electronic Patient Record) direct integration, Oracle Enterprise Edition (Server software), Automatic Scheduling, and RIS MPPS (Modality Performed Procedure Step).

Transcription Software have a specialization inheritance products such as Speech Magic Integration and Speech Recognition. Some customers has specific server, 'Speech Server' hardware for this software.

The Hardware generalization – specialization consists of five main specializations namely Database server, Application Server, Workstation, Speech Server and Support Items. In case of Easy RIS product a minimum requirement of one database server and one application server are mandatory. Hardware support items have main specialization generalization for Monitors, video cards, router accessories, UPS accessory etc.

11.5.2 Cardiology Information System (CIS) – Product- Aggregation –Inheritance

This section describes the Cardiology Information System (from now on referred to as CIS) product family aggregation and inheritance.

CIS has composition aggregation with Software and Hardware. License has direct links to both software and hardware because it has both the configuration related to them.

The software generalization is an abstract class, which does not have any objects, but is used only to inherit from. Software has specialization inheritance towards main objects like Xcelera, Xcelera CLM (Cath Lab Management).

In Xcelera inheritance, the main software application is called Xcelera Base Bundle. Xcelera Base Bundle software can be configured as follows:

- Base Bundle – build up for 1-2 modalities (Ultrasound)
- Advance Bundle - build up for 3-4 modalities
- Premium Bundle - build up for >= 5 modalities

Mainly available workstation's software applications for both Ultrasound and Cath Lab are as follows:

- Standalone Workstation Software
- Integration Workstation for Ultrasound, and
- Integration Workstation for CATH Lab.

Packages available for Ultrasound and CATH Lab are as follows:

- QCA (Quantitative Coronary Analysis)
- LVA (Left Ventricle Analysis)
- CATH viewing
- Ultrasound viewing
- 2D ultrasound quant Mod (Base / Advanced / Premium)
- 3D (Base / Advance / Premium) and
- Pediatric Z-score and Echo Broker for ultrasound.

Under the classification of Xcelera CLM (CATH Lab Management), the main software application is called Xcerlera CLM. Xcerlera CLM software can be configured as follows:

- Base Bundle – build up for 1-2 modalities (CATH Lab Management)
- Advance Bundle - build up for 3-4 modalities
- Premium Bundle - build up for >= 5 modalities

The following are some of the other software used for CLM:

- PROLOG (product name)
- MD reports, Peripheral Angio
- Pace Maker
- CL-Link and
- Haeomosphere.

Note that the CL-Link, software application can be used for both the server and the workstation.

Hardware inheritances for servers are Xcelera, Xcelera CLM, CL-Link, Echo broker, web server and backup. Apart from these there are also workstation, Long Time Archive and Support Items as seen in the figure below.

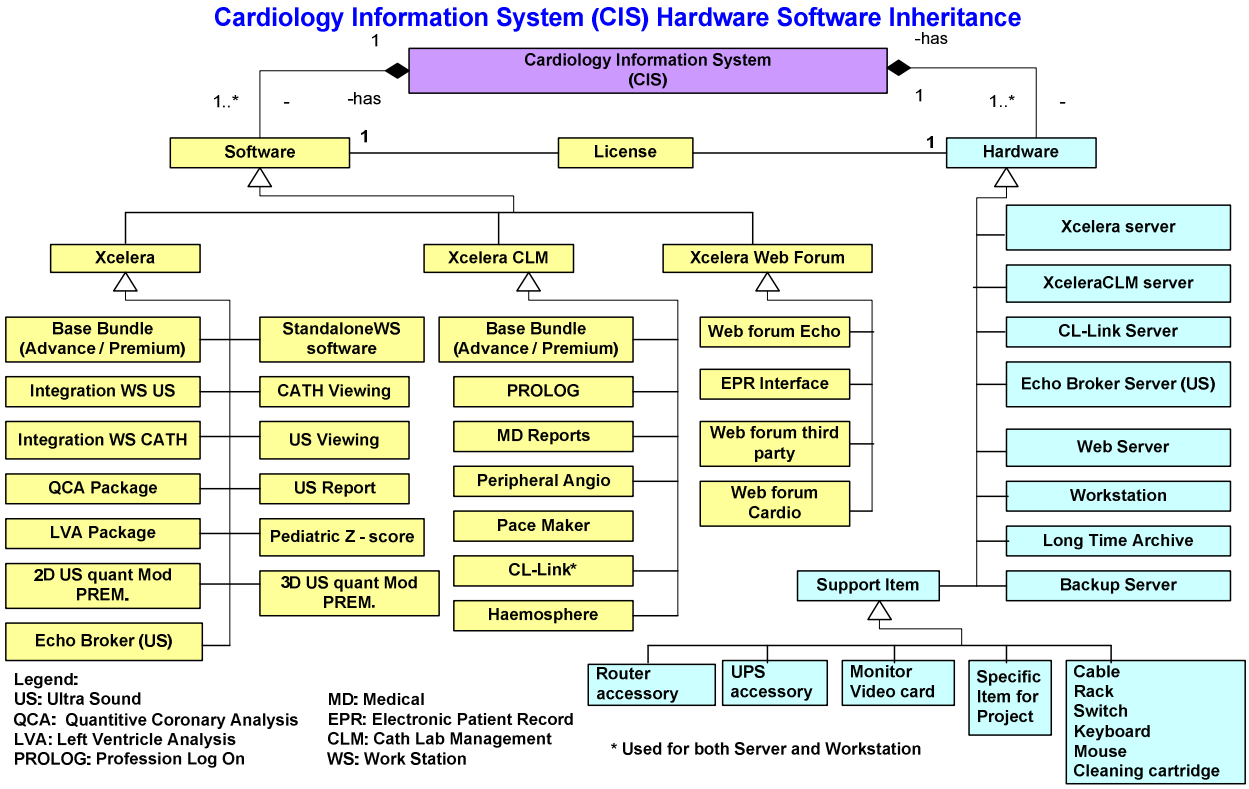

Figure 21: Cardiology Information System – Software Inheritance

11.5.3 Picture Archiving and Communication System's (PACS) Information Systems – Product-Aggregation -Inheritance

This section provides brief information about product aggregation and inheritance in the product family PACS. PACS information System has composition aggregation[27] with Software (SW) and Hardware (HW). License has direct link to both software and hardware because it has both configuration related to HW and SW.

The software generalization is an abstract class, which does not have any objects, but it used only to inherit from. Software has specialization inheritance towards main objects like workstation SW, Server SW, Packages, SW documentation, Support SW suites and Interoperability (functionality). Main specialization inheritances towards products are workstation SW suites like Easy Vision RG, Easy Vision DX and Easy Vision CL. Likewise inheritance for server SW suites are Easy Access (Entry or Enterprise), Easy Access Web, Win 200 Server (Advanced) and SQL 2000 (Advanced). In which, Easy Access (Entry) and Easy Access Web are used for both server and hardware SW.

[27] Composition aggregation is one with strong ownership.

The main inheritances of SW are Merge Port, View Forum and View Forum Volume. Merge Port is used as broker interface. RIS support and Easy Link are mainly used for interoperability.

In case of Packages inheritance, Orthopedic, Multi Planner Reformatting (MPR), Tele-radiology and backup Exec are grouped. Some of support software for PACS are WISE tools, PC Anywhere and Ghost. A few documentation SW suites are used for PACS. Those are Easy DOC Client, Easy DOC Server, Easy Vision DOC Workstation, Easy Vision Workstation User Box and Easy Capture.

The Hardware generalization – specialization consists of six main specializations namely Easy Access Server, Easy Access Web Server, Workstation, Long Time Archive, Backup Hardware, and Support Item. In Support Item inheritance there is some special HW used for documentation, which are 'Documentation EVDX/RG/CL'.

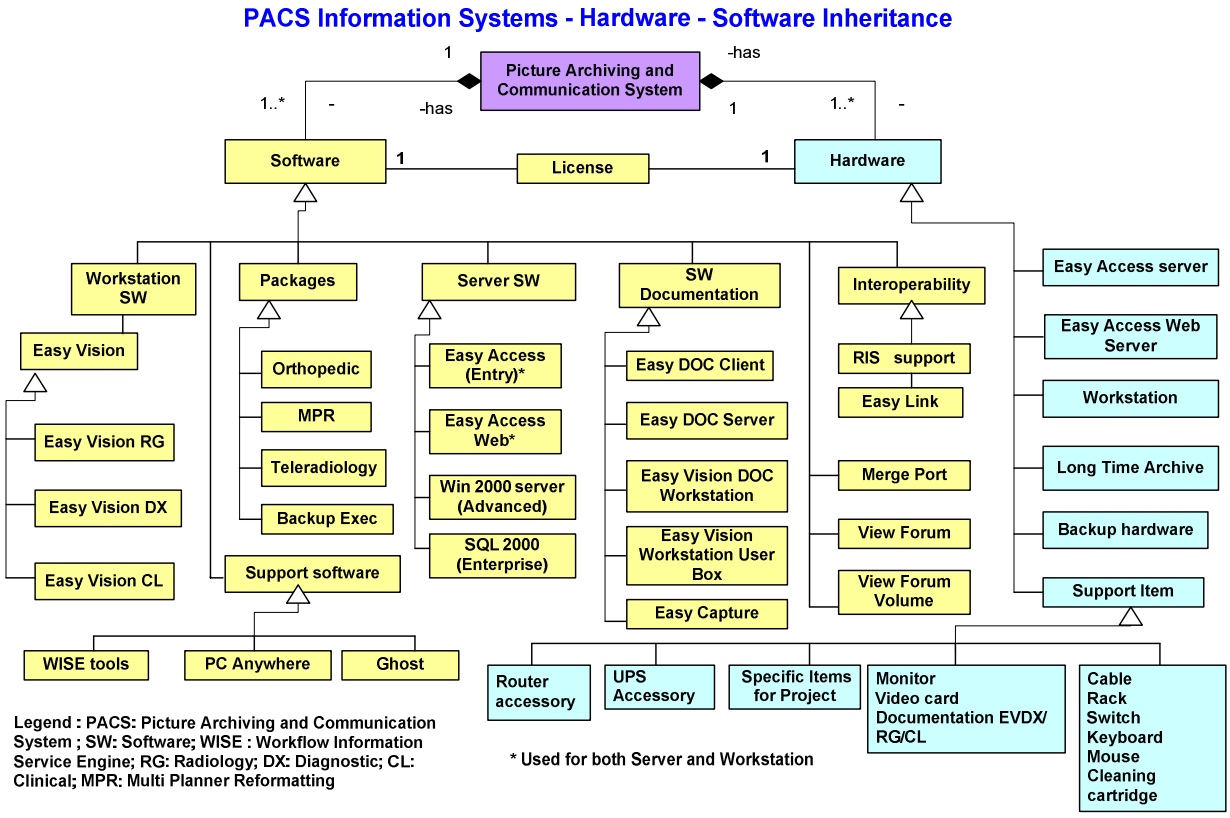

Figure 22: PACS Software Inheritance

11.5.4 Conclusion Information System's Aggregation – Inheritance

Basically section 5.4 provides and describes an overall high-level overview of maximum

configuration of three main information systems, which are Radiology Information System, Cardiology Information System and Information Systems involved in PACS (Picture Archiving and Communication Systems). These aggregation – inheritance diagrams can be used as a library for all three information systems. These diagrams give an idea of the software used in Server and Workstation hardware. The objects of hardware and software in the diagram(s) help in identifying the *Configuration Items* for Installed Base and Configuration Management design.

The information is derived after investigation of various Integrate Test Facility (ITF) Documents, List Of Purchasable Items (LOPI's) and many project and site assessment files seen in Appendix 2.

11.6 Appendix – Introduction to Unified Modeling Language

This section provides basic information and introduction to Unified Modeling Language (from now on referred to as UML). Basic information covers only the notations used in the conceptual data design. To read more about UML refer [9]. The reason behind selecting the UML is discussed in detail in the chapter 2: Research Approach.

Definition UML [9]

> ***UML is a language used to specify, visualize, and document the artifacts of an object-oriented system under development.***

UML provides a very robust notation, which grows from analysis into design. Certain elements of notation (for example, classes, associations, aggregations, inheritance) are introduced during analysis.

Use of UML

The UML is used to model systems (systems can be Information systems, Technical systems, Embedded real-time systems etc.), the range of which is very broad; many different types of systems can be described. UML can also be used in the different phases in the development of a system, from the requirements specification, to the test of a finished system.

11.6.1 Basic concepts

Modeling a complex system is an extensive task. However a single graph or diagram cannot capture all the information needed to describe a system. A system is described by a number of different aspects: functional (its static structure and dynamic interactions), non-functional (timing requirements, reliability, deployment, etc.), and organizational aspects (work organization, mapping to code modules, etc.). Thus a system is described in a number of views, where each view represents a projection of the complete system description, showing a particular aspect of the system.

UML has five basic views namely;

- Use-case view
- Logical view
- Component view
- Concurrency view
- Deployment view

The logical view describes how the system functionality is provided. It describes both the static structure (classes, objects, and relationships) and the dynamic collaborations that occur when the objects send messages to each other to provide a given function.

The static structure is described in class and object diagrams. The dynamic modeling is described in state, sequence, collaboration and activity diagrams. For the Conceptual data design, a class diagram is used.

11.6.2 Class Diagram

A class diagram describes the static view of a system in terms of object classes and relationships among them. To create a class diagram, the classes have to be identified and described; and when a number of classes exist, they can be related to each other by using a number of relationships. A class is drawn with a rectangle, divided into three compartments, the name compartment, the attribute compartment and the operation compartment, as shown in figure 23.

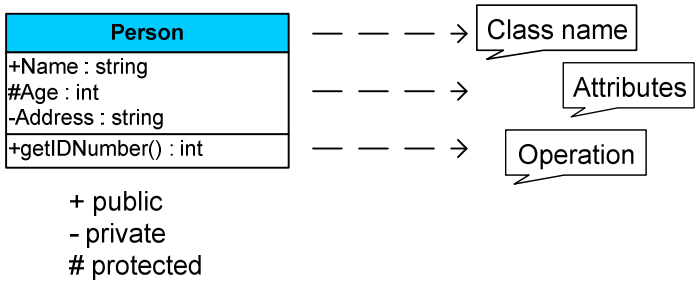

Figure 23: A class in UML

Classes have attributes that describe the characteristics of the objects. Figure 23 shows the class 'Person' with attributes of name, age and address. The class attributes capture the information that describe and identify a specific instance of the class. However, only the attributes that are relevant within the system being modeled should be included. Moreover, the purpose of the system also influences which attributes should be used.

An attribute has a type, which tells what values are allowed, as shown in figure 23. Typical attribute types are integer, Boolean, real, point, area, and enumeration, which are called *primitive*

types.

Relationships
Class diagrams consist of classes and the relationships between them. The relationships that can be used are association, generalization, and aggregation.

- An association is a connection between classes, which means that it is also a connection between objects of those classes.
- A generalization is a relationship between a more general and a more specific element. The more specific element inherits all specifications from the general element and has some additional specifications like attributes and constraints.

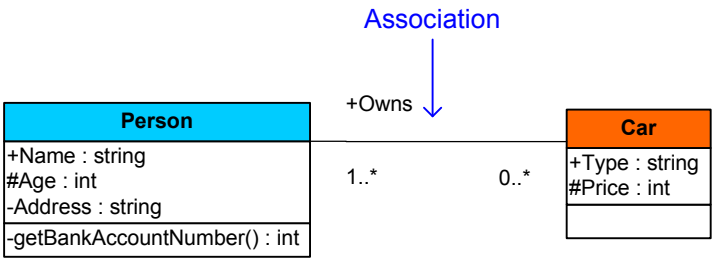

Figure 24: Multiplicity and Association

Figure 24 shows an example where a car can have one or more owners and a person can own zero or more cars. This can be expressed as part of association in a class diagram. To express *how many*, we use multiplicity, a range that tells how many objects are linked. The range can be zero-to-one (0...1), zero-to-many (0...* or just *), one-to-many (1...*). If no multiplicity is specified, then it is one (1) by default. The multiplicity is shown near the ends of the association, at the class where it is applicable (see figure 15).

Aggregation is a special case of association. The aggregation indicates that the relationship between the classes is some sort of "whole-part". When aggregation is used, it often describes different levels of abstraction (a car consists of wheels, engine, etc.). Special kinds of aggregation are the shared aggregate and composition aggregate.

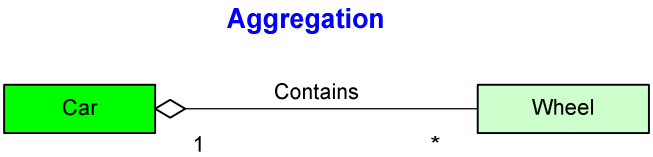

Figure 25: Aggregation

Figure 25 shows, the 'Car' contain many 'Wheels'. Some wheels can be removed and it is still a Car. This is significant for a normal aggregation (but not for a composition aggregation, as described later). The parts (the Wheels) compose the whole (the Car). The hollow diamond

shows the aggregation.

Generalization
Definition of generalization [9] in UML is:

> ***Generalization:***
> ***"A taxonomy (taxonomy is the science of classification) relationship between a more general element and a more specific element. The more specific element is fully consistent with the more general element and contains additional information. An instance of the more specific element may be used where the more general element is allowed".***

Thus, generalization allows elements to be specialized into new elements, so that special cases or extensions can be easily handled as separate elements. A generalization is sometimes called an "is-a" relationship, in that one should be able to say "is-a" between the specialized element and the general element (a car is-a vehicle, a sales manager is-an employee, etc.).

Generalization [9] is a relationship between a general and a specific class. The specific class, called the subclass, inherits all specifications from the general class, called the super-class. The attributes, operations, and all associations are inherited.

A class can be both a super class and a subclass, if it is in a class hierarchy. A class hierarchy is a graph where classes are connected to each other via generalization relationships. Thus, a class can inherit from one class (in which case, it is a subclass to that class) and at the same time be inherited from another class (in which case, it is super class to that class). Generalization is shown as a solid line from the more specific class (the subclass) to the more general class (the super class); with a large hollow triangle at the super class end of the line (see the figure 17).

An abstract class is one that does not have any objects; or, more precisely, it is not allowed to have any objects. An abstract class is only used to inherit from, in that it describes common attributes and behaviour for other classes. In the class hierarchy in figure 17, it is hard to imagine objects that are vehicles that we cannot further distinguish as being a car or a boat. However, the Vehicle class is excellent to capture the commonalties between the car and boat. Vehicle is an example of an abstract class, which doesn't have any objects, but is used only to inherit from.

For example, the Car inherits the attribute color and the operation drive. This means that the attribute color is common for both the Car and the Boat.

Figure 26 shows, a class hierarchy of vehicles. The Car class is subclass to Vehicle, but super-class to Sports car, Passenger car, and Truck.

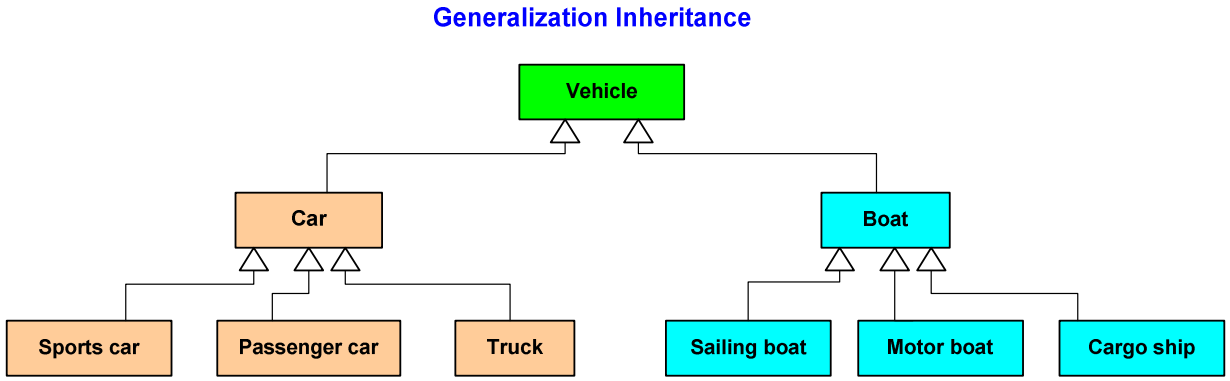

Figure 26: Generalization Inheritance

11.7 Appendix – Symbol and Conventions – Process flow

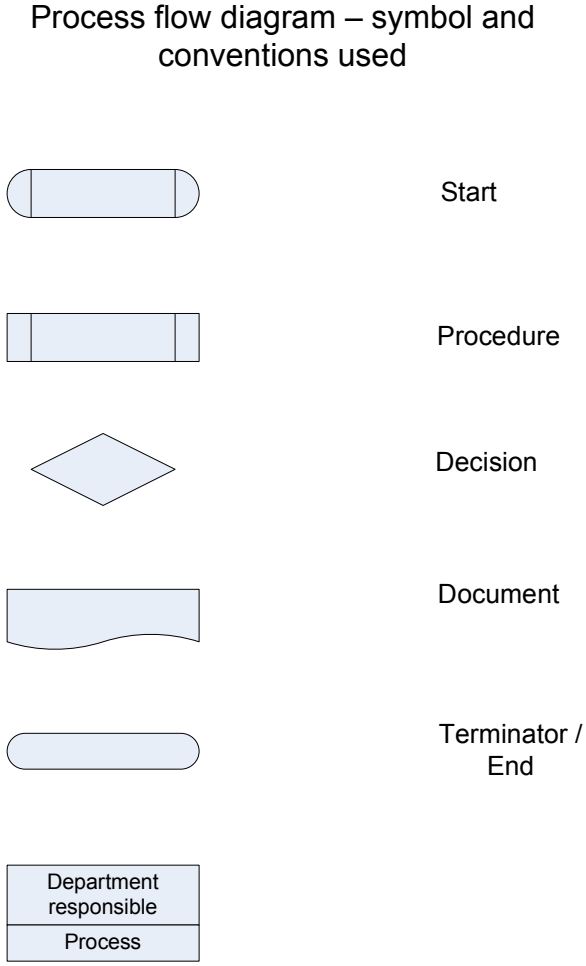

Figure 27: Symbol and Conventions – Process flow