
# Gynaecological Patient Information Management System:

## Functional Requirements

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# 1 Project Scope

## 1.1 Overview of the system

The system should allow data to be entered by medical students, junior doctors and registrars (specialists in training) working in the department. People who enter data should have usernames and passwords (student numbers and HPCSA registration numbers can be used) and they should only be able to enter information and should not have access to data. They should be able to enter data using smartphones, tablets or personal computers in an environment where the hospital is not computerized and computers are not available in the hospital for this purpose.

For purposes of entering data smartphone and tablet applications (apple and android) should be developed to allow smartphone and tablet access to the system.

The data should be securely stored on a site on the Website of the University of Pretoria.

Data will be entered into the system by different employees working in the Department of Obstetrics & Gynaecology at the Kalafong Provincial Tertiary Hospital.

Data of patients entered should include both the patient's hospital number as well as RSA Identity number.

The possibility of linking this system to that of the National Health Laboratory System (NHLS) should be investigated to make it possible to access laboratory results through this system. The NHLS has an online accessibility.

The administrator of the system should have access to all relevant data. The different levels and specifications of data output will be defined upfront and the ability should exist to add or edit these specifications as required.

Patient information and data are highly confidential and the website and information should be secure. All users will have to use a username and password. Medical students can use University of Pretoria student numbers and medical interns, medical officers and registrars can use their Health Professions Council of South Africa (HPCSA) unique registration numbers. Doctors and students rotate through the department for different time periods and the usernames and passwords should expire depending on the different categories. Students rotate for four weeks, medical interns for four months and medical officers and registrars for up to five years. Administrative staff and consultants are more permanent and for security reasons should perhaps update information yearly.

## 1.2 Patient Information Management System - Global Scope

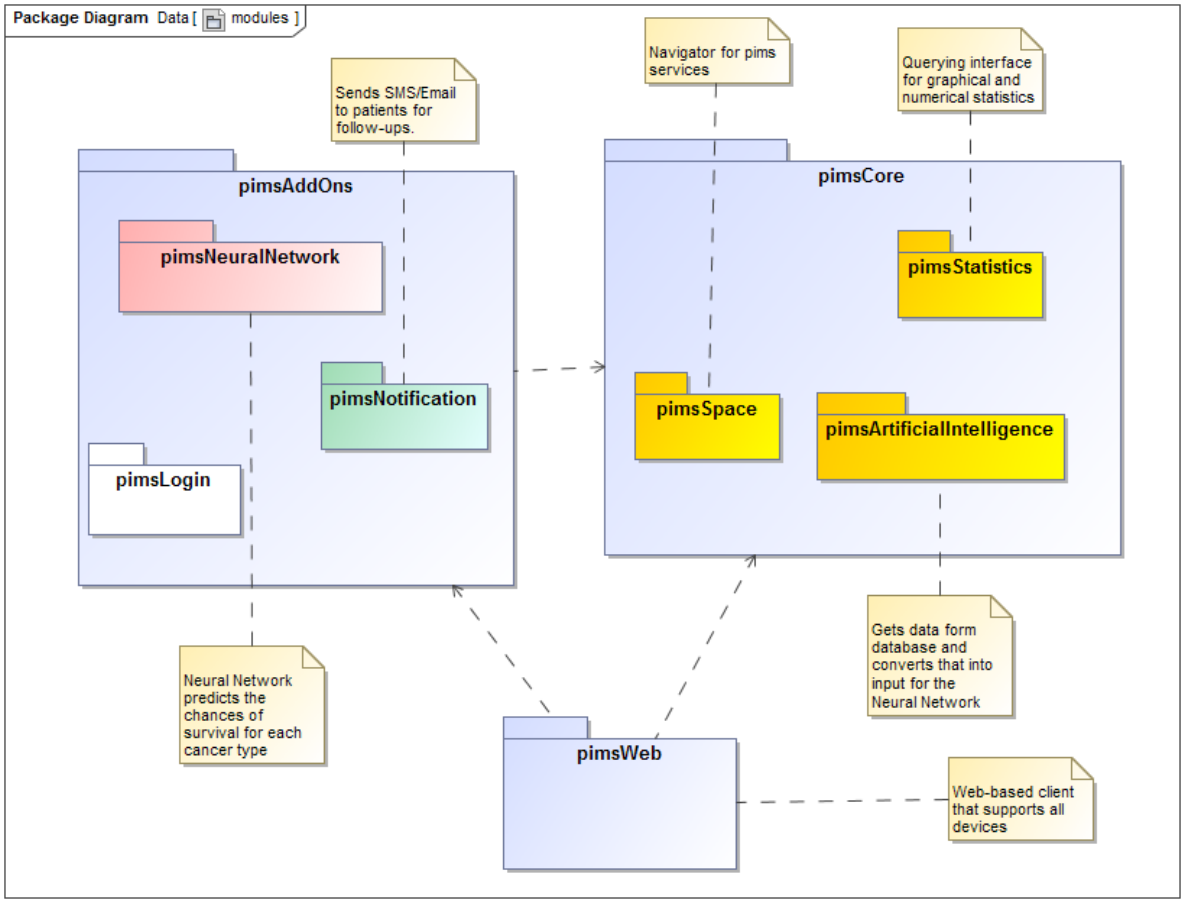


Figure 1: Global scope for PIMS

# 2 Application requirements and design

## 2.1 PIMS Login Module

This module is responsible for allowing a user to login into and logout out of Pentec Patient Information Management System. A user should login with the credentials they were assigned upon registration. If the user is not assigned a user name then an exception is thrown and the user is redirected to the login page.

To avoid "Spambots", a reCAPTCHA challenge is used.

### 2.1.1 Scope

The scope is shown in the use case diagram below:

Figure 2: Login module scope

### 2.1.2 Use cases

**loginToPIMS – [priority: critical]** This use case is to cater for the logging in of user into the system. It entails the authentication of each user as well as their authorization, which is based on their access rights.

**Service Contract** The service contract for loginToPIMS is shown below.

Figure 3: Service contract for pimsLogin

**logoutOfPIMS – [priority: critical]** This use case logs a user out of the system by destroying the session. The user will not be allowed access unless they log back in.

**Service Contract** The service contract for logoutOfPIMS is shown below.

Figure 4: Service contract for logoutOfPIMS

**authenticateUser – [priority: critical]** This use case makes sure that only registered users can use PIMS. It also manages the user rights so that users only access what's intended for them. If a normal user tries to access admin pages, then they are redirected to a page that applies to their access rights.

## 2.2 PIMS Statistics Module

This module is responsible for displaying statistics from the database. The user has an option to choose the type of graph (either a bar chart or line graph).

### 2.2.1 Scope

The scope is shown in the use case diagram below:

Figure 5: PIMS statistics module scope

### 2.2.2 Use cases

**viewStats – [priority: critical]** This use case is a generic version of all statistics to be obtained. Sub-use cases follow the same contract, but return different data.

**Service Contract** The generic service contract for all statistics is shown below.

Figure 6: Service contract for viewStats

**Process Specification** The generic process specification for all statistics is shown below.

Figure 7: Process specification for viewStats

**createGraph – [priority: critical]** This use case creates and displays a graph. This graph can be viewed by the client or downloaded for record keeping.

### 2.2.3 Equations

**Statistics Average Equation**

$$AM = \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{x} a_j$$

**Graph Equation**

$$f(x) = \sum_{i=1}^{n} x_i$$

## 2.3 PIMS Artificial Intelligence Module

This module is responsible for predicting the chances of survival for each cancer type. Parameters for each patient are considered to compute this prediction. These parameters are converted into a single value that will be used by the PIMS Neural Network Module as input.

### 2.3.1 Scope

The scope is shown in the use case diagram below:

Figure 8: The global scope for PIMS Artificial Intelligence Module

### 2.3.2 Use cases

**getAverageSurvivalRatePrediction – [priority: critical]**

**Service Contract** The generic service contract

Figure 9: Service contract for getAverageSurvivalRatePrediction

**getPatientChanceOfSurvival – [priority: critical]**

**Service Contract** The generic service contract

Figure 10: Process specification for Service contract for getPatientChanceOfSurvival

### 2.3.3 Neural Network Training

Patient data was analysed for possible risk factors for cancer susceptibility. These risk factors are:

- Age - No normalization was required for this field. However, decimal scaling was used for the age. Patients are expected to be within the age range of [16 - 100] so the age is scaled-down to two decimal places.

- HIV status - Is a binary field (either negative or positive). Negative HIV statuses were given the numerical equivalent of 0.9 while a positive status holds 0.1.
- CD4 count (If HIV status is positive) - If the patient is HIV negative, the numerical values becomes 0.9998. Otherwise, decimal scaling (4 places down) is used since the CD4 range is 0 - 1500.
- Figo Stage - Since this value is neither binary nor numeric, the number of figo stages determines how the patient's stage is normalized. If there are n stages then the kth stage gets the numerical equivalent of $\frac{k-stage}{n}$
- Site of distant metastase
- Histology
- Differentiation
- Primary treatment
- Type of surgery
- Type of radiotherapy
- Response to treatment
- Relapse
- Last known vital status

The Neural Network makes use of the back-propagation algorithm for the purpose of learning.

- The equations used for the neural network are as follows:
  - Input Function:

$$net = \sum_{i=1}^{n} x_i w_i$$

  - Hidden layer Input Function:

$$net_{y_i} = \sum_{i=1}^{I+1} z_i w_j i$$

  - Hidden layer Sigmoid Activation function:

$$y_j = \frac{1}{1 + e^{-net_{y_j}}}$$

  - Output layer Input Function:

$$net_{o_k} = \sum_{j=1}^{I+1} y_j w_k j$$

– Output layer Sigmoid Activation function:

$$o_k = \frac{1}{1 + e^{-net_{o_k}}}$$

– Sigmoid Activation function:

$$f(net) = \frac{1}{1 + e^{-net}}$$

– Training error:

$$Error = (t_k - o_k)$$

– The equations used for the back propagation phase are as follows:

* Output layer error propagation:

$$\delta_{o_k} = -(t_k - O_k)(1 - O_k)O_k$$

* Output layer weights propagation:

$$w_{k_j} o_k \mathrel{+}= -(\delta_{o_k} y_j$$

* Hidden layer error propagation:

$$\delta_{y_j} = -(w_{k_j} \delta_{o_k} (1 - y_j) y_j$$

* Hidden layer weights propagation:

$$v_{j_i} \mathrel{+}= \delta_{y_j} z_i$$

### 2.3.4 Neural Network Testing

When testing the network, a the critical cancer parameters are normalized given a patient name. When classifying the patient as likely to survive or die form cancer the principles of a statistical probability density function, $^2$-distribution are applied; wherein the null hypothesis is $(H_0)$:

- A patient is likely to survive cancer

in order to obtain a confidence interval for the survival prognosis. A 50% significance level is used for the confidence interval; such that 50% of the time, the output node value is likely to be a false positive and as for the other percentage, one can be confident in it as being accurate. The choice of the application of the $^2$-distribution is plainly for it's simplicity and it is a well known probability density function. The choice of the confidence interval was aided by the application of artificial neural networks in survival analysis when compared with other survival analysis statistical models [**?**].

- The below $^2$-distribution formulas are used:

  – Probability: [1]

$$\chi^2 = \frac{1}{d} \sum_{k=1}^{n} \frac{(O_k - E_k)^2}{E_k}$$

[1] $n$ is the number of patients to test, $E$ is the target, $O$ is the output node value, $k$ *is the individual patient*

– Confidence interval: [2]

$$\pm \frac{(n-1) \times s^2}{\chi^2_{\frac{\alpha}{2}} \times (n-1)}$$

– Degrees of freedom:

$$(n-1)$$

- The $^2$-distribution table of critical values will be used to test $(H_0)$

Figure 11: Snippet of Chi-squared distribution critical value table

## 2.4 PIMS Notification Module

This module is responsible for sending email/SMS notifications to a patient. This email/-text message could be a reminder to a patient about follow up visits to the doctor.

### 2.4.1 Scope

The scope is shown in the use case diagram below:

Figure 12: The global scope for PIMS Notification Module

### 2.4.2 Use cases

**findPatient – [priority: nice-to-have]** This use case is to cater for the retrieval of a patient ID/name form the database so as to obtain the contact details of the patient, if any.

**Service Contract** The service contract for findPatient is shown below.

Figure 13: Service contract for findPatient use case

**sendNotification – [priority: nice-to-have]** This use case is to cater for the sending follow-up notification messages via SMS or email depending on whether or not the patient has an existing cellphone number or email.

**Service contract** The service contract for sendNotification is shown below.

Figure 14: Service contract for sendNotification

**Process specification** The process specification for sendNotification is shown below.

Figure 15: Process specification for sendNotification

[2] $s$ is the mean square error

## 2.5 PIMS Space Module

This module is responsible for providing all the core functionality of Patient Information Management System. The front-end component displays all the available services to the user.

### 2.5.1 Scope

The scope is shown in the use case diagram below:

Figure 16: Scope for PIMS Space Module

### 2.5.2 Use cases

**getPIMSSpace:**

**Service Contract**

Figure 17: Service contract for getPIMSSpace

completeForm:

**Service Contract**

Figure 18: Service contract for completeForm

viewTutorial:

addNewUser:

**Service Contract**

Figure 19: Service contract for addNewUser

removeUser:

**Service Contract**

Figure 20: Service contract for removeUser

viewTotalFormSubmitted:

getIncompleteForm: