# SOFTWARE REQUIREMENT SPECIFICATION (v. 0.9)

# Self-Optimizing Personalized Health Assistant

**Intelligent System for Assisting Personalized Health Assistance**


**Jan. 2023**

## DUE DATES

| | Scope of AD | Due Date | Length Limit |
|---|---|---|---|
| **Interim Report** | Chapters 1, 2, 3 | 2/1(Wed), 9pm | 30± Pages |
| **Pre-Final Report** | Chapters 4, 5 | 2/14(Tue), 9pm | 50± Pages |
| **Final Report** | Chapters 6, 7 | 2/27(Mon), 9pm | 70± Pages |

## CEP INSTRUCTOR

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# Self-Optimizing Personalized Health Manager

## 1. Purpose of the Document

The purpose of this document is to specify the requirement for developing the target system in this CEP. The requirement will become the basis for designing the software architecture of a target system, which is required as a fulfillment to acquire the Samsung Associate Architect (AA) certification.

## 2. Comprehensive Evaluation Project (CEP)

### 2.1. About Associate Architect (AA) Program

Associate Architect Program of Samsung Electronics is to provide participants with two sets of software architecture design proficiency.

- **Body of Knowledge (BoK) on Software Architecture**

  This set includes the fundamental theories and methods for designing SW architecture

- **Skillset for Designing SW Architecture**

  This set includes the practical skill for applying architecture design methods to a given SRS.

CEP is designed to fulfill the second set of AA program through an individual design project.

### 2.2. How is the CEP problem prepared?

The CEP problem is prepared by the instructor, based on the following principles.

- **Principle 1. Utilizing the Whole BOK of Software Architecture Design**
  - Utilizing Architecture Styles
  - Designing Architecture for multiple Views
  - Designing Architecture for Non-Functional Requirements
- **Principle 2. Handling the Complexity of Industrial Systems**

  The target system to design in CEP is an industry-level complex software system, i.e., not an academic problem appeared in books or literature.

- **Principle 3. Solution Not Available in Public**

  CEP problem is not a reproduction of already existing exercise problem in books, and hence the architecture design solution for the CEP problem is not available in public.

## 2.3. Architecture Design Reports in CEP

Each participant designs and submits the design of software architecture for the target system in incremental manner.

- Interim Report
  This report includes the context analysis model and the skeleton architecture design of the target system.
- Prefinal Report
  This report includes the architecture design for multiple views of the system: functional view, information view, behavior view, and deployment view.
- Final Report
  This report includes the architecture design for non-functional requirements and the validation of the architecture design.

❑ **Weight Distribution of CEP Reports**

| Interim Report | Prefinal Report | Final Report | TOTAL |
|---|---|---|---|
| 25 points | 35 points | 40 points | **100 points** |

## 2.4. Template for Architecture Design

A template for designing the software architecture in CEP is provided and hence participants can utilize the template in specifying the architecture design. The template is devised to be consistent with the architecture design methodology provided by the instructor.

❑ **Filename**

AA-2023-A1, CEP, AD Template.docx

# 3. Overview of the Target System

## 3.1. What is the Personalized Health Assistant?

*Personalized Health Manager* is a software system that (1) acquires various health indexes of users, (2) acquires the health-relevant activities such as food consumption, performed exercises, and stress level, (3) determines the effectiveness of the performed activities, and (4) recommends health-promoting activities to users.

To recommend the health-promoting activities, the system should maintain a knowledgebase of health-relevant activities and their relevance on health indexes. Note that the effectiveness of a same health-relevant activity such as treadmill exercises of 40 minutes vary among people. Therefore, the system should also maintain a knowledge of users' personal effectiveness of the activities on the health indexes.

## 3.2. About Health Indexes

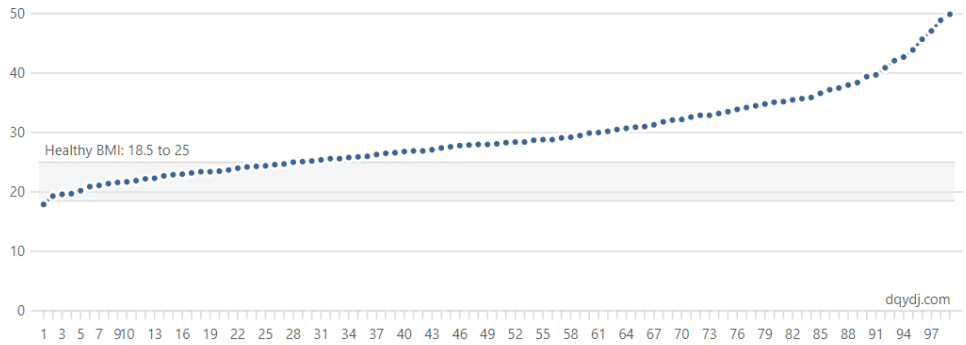
A health index is a quantitative measurement of a human body condition. The set of representative indexes are given below.

❑ **Weight (몸무게)**

Body weight is the measurement of weight without items located on the person. It is measured using manual or digital weighing scales. The unit is kg or lb. Body weight can vary throughout the day depending on the amount of water in the body, food eaten and excretion.

❑ **BMI (체질량 지수)**

Body Mass Index (BMI) is a value derived from the mass and height of a person. It is defined as (Body Mass divided by Square of Body Height) the unit of kg/m². The distribution of BMIs among age groups for USA is shown below.



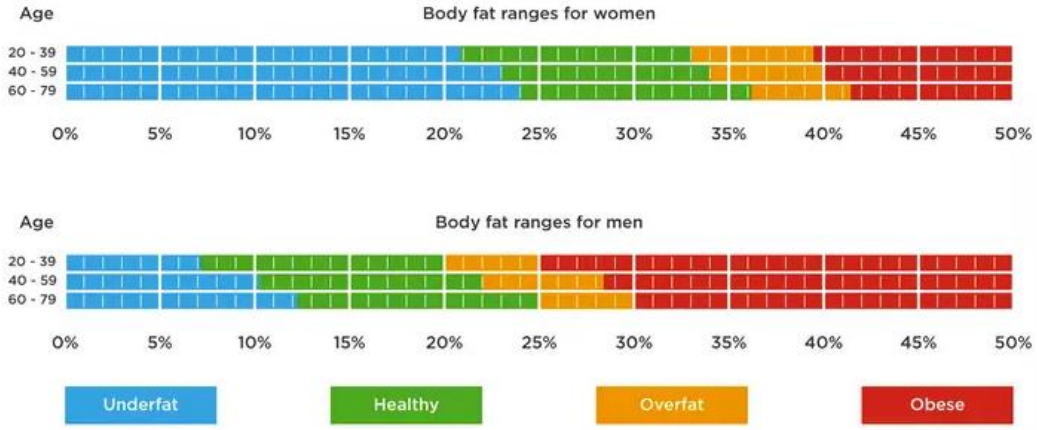

❑ **Body Fat Percentage (제지방율)**

Body Fat percentage (BFP) is the total (mass of fat) divided by (total body mass), multiplied by 100. It includes essential body fat and storage body fat.

❍ Essential Body Fat is necessary to maintain life and reproductive functions.

❍ Storage Body Fat consists of fat accumulation in adipose tissue, part of which protects internal organs in the chest and abdomen.

The body fat percentage is classified as four groups depending on the measured rate as shown below.




❑ **Fat-free Body Weight (지방제외 체중, 무지방체)**

Fat-free Body Weight refers to all of the body components except fat. It includes the body's water, bone, organs, and muscle mass.

An FFMI higher than 17 (for women) or 20 (for men) is desirable.

❑ **Subcutaneous Fat (피하지방)**

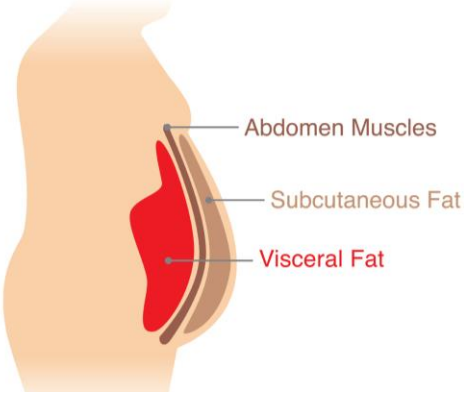
Subcutaneous Fat is fat that we can pinch and is found just under our skin. Some subcutaneous fat is good for your body and helps protect it. But too much body fat overall can lead to serious health issues including heart disease, diabetes, stroke and more.

❑ **Visceral Fat (복부 지방)**

Visceral Fat is fat that wraps around abdominal organs deep inside body. The correct location and amount of visceral fat can be measured using imaging tests, i.e., CT and MRI.

Therefore, it is typically measured by the waist-hip ratio (WHR) for the waist size over hip size. WHR is classified as three health risk; ≤0.8 for women and ≤0.95 for men as low risk, 0.81~0.85 for women and 0.96~1.0 for men as moderate risk, and ≥0.86 for women and ≥1.0 for men as high risk. Moreover, the visceral fat area approximately 100cm$^2$ is calculated. It is classified 60 levels and the levels can be classified as three groups; ≤9 for standard, 10~14 for high, and ≥15 for very high.

Although the main purpose of visceral fat is the protection of abdominal organs, too much amount of this fat occurs serious medical issues, such as hear disease, type 2 diabetes, stroke, and high cholesterol. The location of subcutaneous fat and visceral fat in abdomen are shown below.



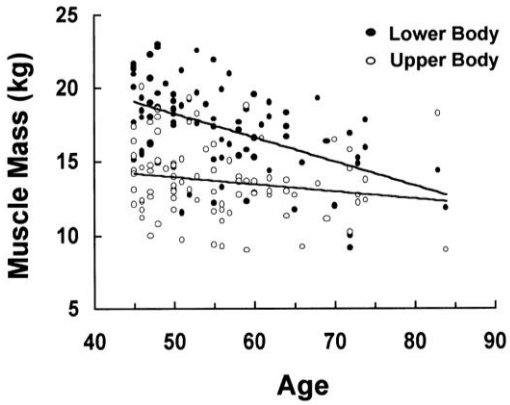

- **Body Water (체수분)**

  Body water is the water content contained in the tissues, the blood, the bones and elsewhere. The average of body water percentage of body weight is about 60%. It can be different depending on the age and gender. The older, the less percentage of body water is contained in the body. Maintaining the certain rate of body water is important because it is mandatory to build cells, metabolize and transport nutrients, maintain body temperature, protect body from shock, and etc.

- **Skeleton Muscle (골격근)**

  Skeleton muscles are voluntary muscles that control all sections of body consciously. These muscles make up between 30 to 40% typically. Shoulder muscles, abdominal muscles and other muscles attached at skeletons are examples of the muscle. It is difficult to measure the correct skeleton muscle mass without precise machine. Alternatively, the skeleton muscle mass is measured by formula for body composition.

  According to research for distribution of muscle mass and age, as people get age, the skeleton muscle mass decrease as shown below

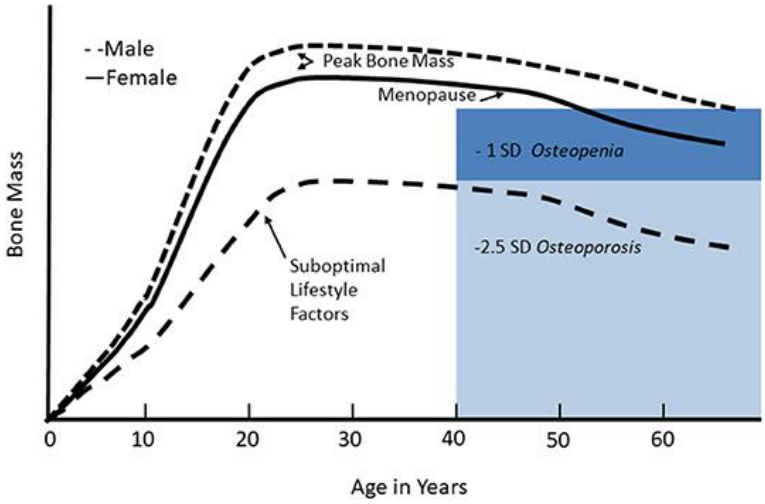



- **Muscle Mass (근육량)**

  Muscle mass is measured by the size of skeleton muscle, visceral muscle, and cardiac muscles. It typically means only skeleton muscle. Because all muscle are applied to maintain life activities, such as breathing, resisting insulin, and heart beating, it required sufficient mass in a body.

❑ **Bone Mass (골량)**

Bone mass is a measure of the amount minerals contained in a certain volume of bone. The bone mass is measured by T-score for the bone mineral density. The lower standard deviation (SD) of bone density (close to 1), it means the dense bone. If the bone mass is too low, i.e., over 2.5 SD from T-score, osteoporosis and osteopenia can occur. The bone mass increase to about mid of 20 and decrease continuously during remained age as shown below.



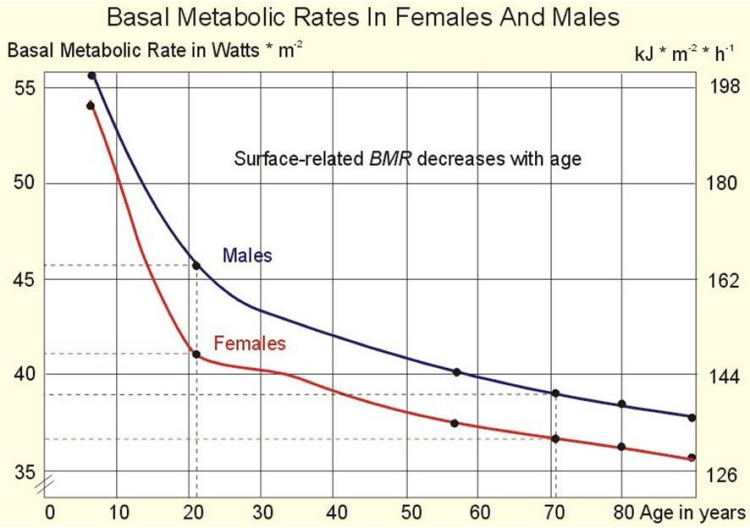

❑ **Protein (체내 단백질함량)**

Protein mass is the amount of protein in the body. The healthy range of protein mass in the body is 17% or more. Protein is one among multiple body composition instances and low protein mass can be associated with high body fats. Therefore, daily calories for a person should consist of up to 12 to 20% of protein. In addition, the older, the more amount of protein in a daily calories is required because of anabolic resistance which lowers the body's ability to break down and synthesize protein.

❑ **BMR (기초대사율)**

Basal Metabolic Rate (BMR) is the rate of energy expenditure per unit time by a person at rest. It is reported in energy units per unit time ranging from watt (joule/second) to ml O2/min or joule per hour per kg body mass J/(h·kg). The BMR can be affected depending on multiple variables, muscle mass, age, genetics, gender, weather, diet, pregnancy, and supplements. There are multiple equations to measure BMR, such as Mifflin-St Jeor Equation, Harris-Benedict Equation, and Katch-McArdle Formula.

The BMR decease depending on the age as shown below.




- **Metabolic Age (대사 연령)**

  Metabolic age is calculated by comparing a person's basal metabolic rate to an average of the person's chronological age group. The higher BMR, the younger (better) metabolic age.

## 3.3. About Health-Relevant Activities

A health-relevant activity is a human's activity that has some impacts on the health indexes such as BMI, Body Fat, and Protein Level. There can be different types of activities that are relevant to health indexes of people.

There exists no standard taxonomy of health-relevant activities. In this system development, the following categories of health-relevant activities.

- **Water and Beverage Consumption**
- **Food Consumption**
- **Physical Exercise**
- **Health Food Supplements**
- **Mental State**

## 3.4. About Effectiveness of Health-relevant Activities

A health-relevant activity has a positive or negative effectiveness on maintaining human's health condition, i.e., the values of health indexes. Consider the following examples.

- Activity with Positive Effectiveness

  Activities such as regular cardio exercise and healthy diet will have a positive effectiveness on promoting the health condition by lowering the body fat level and BMI.

- Activity with Negative Effectiveness

  Activities such as consumption of fatty foods and a lack of physical exercises and a will

have a negative effectiveness on promoting the health condition by increasing fat level and weakened muscle.

## 3.5. Process of Managing Health Condition

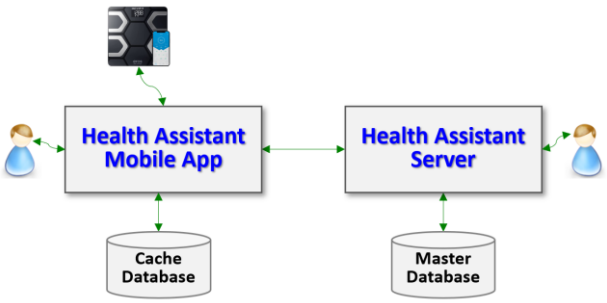
The process of managing the health condition by utilizing the system is a sequence of the following steps.

- Step 1. Enter users' health profile including age, weight, and heights.
- Step 2. Initialize the U_EK and P_EK for the user.
- Step 3. Enter initial Health Index measurements.
- Step 4. Recommend the personalized health-promoting activities.
- Step 5. Enter the Health Index measurements after performing the activities.
- Step 6. Analyze the effectiveness of performed health-promoting activities.
- Step 7. Update the P_EK with the new effectiveness analytics.
- Repeat the steps 4 through 7.

Beside the main process, there should be a software thread for checking the need for updating U_EK. If needed, the U_EK is updated.

## 3.6. Deployment of the System

There are two groups of users in this system: end-users and system operation staffs. The system considers of a mobile app for end-users and a server for the staffs as shown below.




- **Health Assistant Mobile App**

  This mobile provides the whole functionality of end-users. It utilizes the functionality of the server in delivering the whole functionality to end-users.

  This app may connect health monitoring devices that can measure the values of health indexes including the body weight. It maintains a cache database for high data availability.

- **Health Assistant Server**

  The server provides the functionality with high complexity for the mobile app and the functionality for the system operators, i.e., staff members. It also maintains the master database.

# 4. Functional Requirements

The functionality of the system is organized as a set of functional categories.

## 4.1. User Profile Management

This functionality is to manage the profiles of users who invoke the main functionality of the system. When registering, a user provides his or her identification information, contact information, login information, and credit card information.

## 4.2. Staff Profile Management

This functionality is to manage the profiles of staff members who manage the system operations. When registering, a staff member provides his or her identification information, contact information, login information, and departmental information.

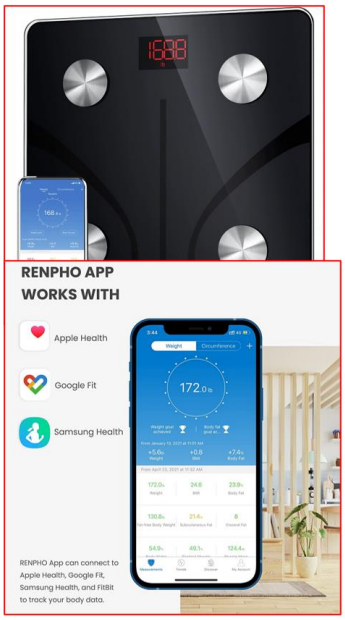
## 4.3. Health Monitoring Device Registration

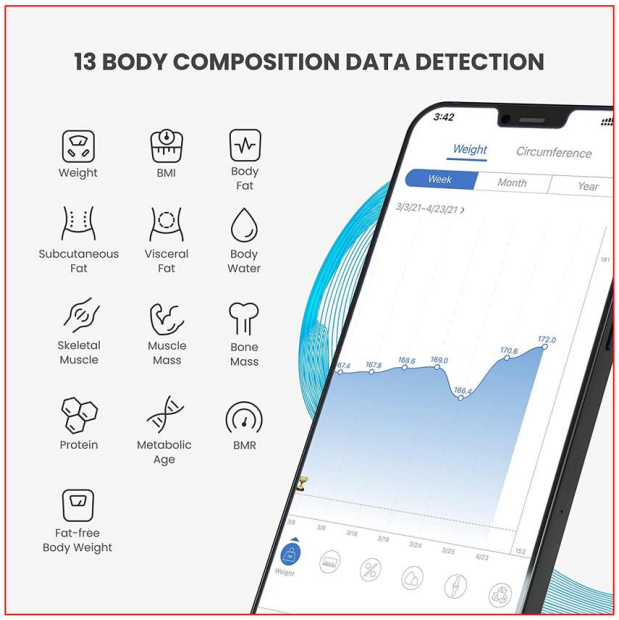
This functionality is to register health monitoring devices for measuring health indexes. Modern high-end weight scales provide the capability of measuring health condition using health indexes beyond the body weight.

Several different models of health monitoring scale are available on market, and they all provide Bluetooth connectivity to mobile apps for storing the measured health indexes and analyzing the indexes.

Some of the representative devices are shown below.

- **RENPHO Smart Scale**



- **INEVIFIT EROS Scale**


- **Weight Scale providing 15 Health Indexes**

  Some of the weight scales provide more types of health indexes.

- **API for Connectivity**

  Each device provides its own mobile app for Bluetooth connection and health index acquisition. Some of the devices provide an open API for connecting various mobile apps.

## 4.4. Acquisition of Health Indexes

This functionality is to acquire health indexes of users, and the following health indexes are considered in the initial version of the system.

- Weight
- BMI
- Body Fat
- Fat-free Body Weight
- Subcutaneous Fat
- Visceral Fat
- Body Water
- Skeleton Muscle
- Muscle Mass
- Bone Mass
- Protein
- BMR
- Metabolic Age

The system acquires the health indexes in two ways: *Directly from Device* or *Manually from User*.

- **Reading Health Indexes from Device**

  This is to automatically acquire measured health indexes of users directly from a connected weight scale device.

- **Entering Health Indexes Manually**

  This is to allow users to manually enter their health indexes when there is no connected device. A user may use a weight scale which does not support API for Bluetooth connection and hance the user has to enter the measured values on a keyboard. Or, a user may visit a medical clinic, let their health indexed measured there, and manually enter the results.

### 4.5. Acquisition of Health-Relevant Activities

This functionality is to acquire the health-relevant activities performed by a user. A user enters all the activities performed in recent days or weeks. Each activity is entered as a tuple of 3 elements, (Category, Sub-category, Intensity).

- Category
  This is the main type of activities, such as Water/Beverage Consumption and Physical Exercise.
- Sub-category
  This is the secondary type of each main type, such as Jogging for Physical Exercise category.
- Intensity
  This is a numeric level of intensity for each performed activity, such as 30 minutes for Jogging.

For the initial version of the system, the following taxonomy of the activities is applied.

#### 4.5.1. Water/Beverage Consumption

- **Water**
- **Coffee**
- **Soda**
- **Tea**
- **Others**

#### 4.5.2. Food Consumption

- **Meat**
- **Vegetable**
- **Fruits**
- **Ingredient levels**
  - Salt Level
  - Sugar Level
- **Fishes**
- **Snack containing high amount of sugar**
- **Others**

#### 4.5.3. Physical Exercise

- ❑ **Swimming**
- ❑ **Jogging**
- ❑ **Running on Running Machine**
- ❑ **Weight Training**
- ❑ **Stretching**
- ❑ **Others**

#### 4.5.4. Health Food Supplements

- ❑ **Vitamin**
- ❑ **Omega**
- ❑ **Protein**
- ❑ **Others**

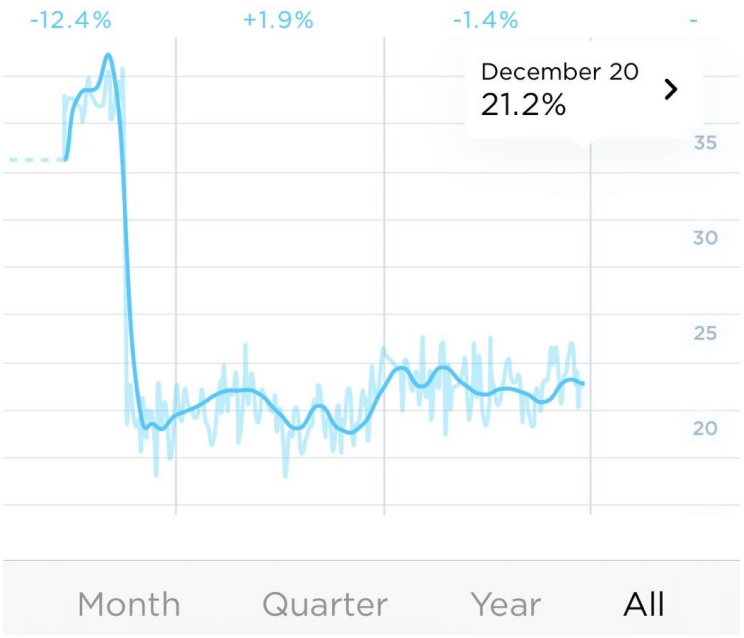
#### 4.5.5. Mental State

- ❑ **Degree of Busyness**
- ❑ **Degree of Stress**
- ❑ **Hours of Sleep**
- ❑ **Others**

### 4.6. Analytics of Health-Relevant Activities on Controlling Health Indexes

This functionality is to analyze the effectiveness of health-relevant activities on controlling health indexes of users. Each activity may have some influence on controlling health indexes. For example, a regular diet and cardio exercise has influence by lowering the body fat percentage.

The effectiveness of health-relevant activities can be measured by considering the history of health indexes for a period of time. The following figure shows the changes of the body fat by different periods.




- **Relevance of the Activities on Health Indexes**

  The relevance between the activities and the health indexes can conceptually represented as a matrix.

| Category | Sub-category | Intensity | $HI_1$ | $HI_2$ | … | $HI_n$ |
|---|---|---|---|---|---|---|
| … | | | | | | |
| … | | | | | | |
| Physical Exercises | Running | 30min/each, 4times/week | 0.5 | 0.2 | -0.3 | 0.6 |
| … | | | | | | |

  Each entry in the table has a relevance as a numeric value between -1 and 1. The value of 1 is 100% positive influence and -1 is 100% negative influence, i.e., not relevant at all.

  Note that this table of Relevance is maintained for each user since the relevance of a health-related activity on each health index will vary among people.

The system should apply advanced software analytics methods to analyze the relevance and maintain the personal table of relevance.

## 4.7. Recommendation of Health-Promoting Activity

This functionality is to recommend the health-promoting activities for each user based on the personal effectiveness of health-relevant activities performed.

The recommendation of the activities to perform is made in two steps.

- **Step 1. Recommend using the Universal Effectiveness Knowledgebase**

  Universal Effectiveness Knowledgebase (U_EK) is the general knowledgebase that maintains the relevance of health-related activities on health indexes. This table can initially be created by healthcare human specialists.

  This step is to identify the desirable health-promoting activities by considering the current health indexes of each user and using U_EK.

  It is expected that a user would enhance his or her health by performing the recommended activities.

- **Step 2. Refine the Recommendation using the Personal Effectiveness Knowledgebase**

  Personal Effectiveness Knowledgebase (P_EK) is a user-specific personal knowledge that maintains the relevance of health-related activities on health indexes. The relevance values in this table are automatically computed by the system by observing the health-related activities performed recently and their influences on the health indexes.

  This step is to refine the health-promoting activities recommended in step 1 by using the P_EK. Hence, this step is essentially to personalize/customize the recommendation by considering each user's individual health-related features.

## 4.8. Self-Optimizing Effectiveness Knowledgebase

This functionality is to optimize the U-EK and P_EK on demand.

### 4.8.1. Optimizing Personal Effectiveness Knowledgebase

The P_EK could be updated by the system whenever a user performs a session of entering the health indexes and performed health-related activities. The system analyzes the relevance of the performed activities on controlling each health index and accordingly update the knowledgebase.

### 4.8.2. Optimizing Universal Effectiveness Model

The U_EK is meant to be stable and generically applicable to all users. However, the content of U_EK should be updated when the U_EK does not reflect recent trends and results of the relevance of health-related activities on health indexes.

Another way of determining the need for optimizing U_EK is to measure the gap between the initial recommendation made in step 1 and the refined recommendation made in step 2. If the average gap between the two recommendations is high, then the U_EK may be outdated.

## 4.9. Report Generation

This functionality is to generate two types of reports.

### 4.9.1. Generating Personal Reports

A user may request a personal report that includes the history of health indexes measured, health-related activities performed, the effectiveness of the activities on controlling health indexes, and the health-promoting activities recommended by the system.

The personal report should utilize tables, charts, and figures for high comprehensibility.

### 4.9.2. Generating Business Reports

A business report includes the history of the business operations on the system. A set of pre-specified reports are periodically generated. Reports can also be generated on demand.

# 5. Non-Functional Requirements

There can be several non-functional requirements that are essential in the target system. For CEP, we consider only 2 NFR items.

## 5.1. NFR-1. High Effectiveness of Recommended Activities

A key functionality of the target system is to recommend users with health-promoting activities. This recommendation made by the system should highly be effective on promoting the healthiness of users.

When the recommended activities are not sufficiently effective in promoting health condition, users will experience the waste of valuable time and effort spent for performing the activities.

- **Recommendation and Effectiveness Knowledgebases**
  - Both U_EK and and P_EK become the basis for deriving the recommendation of health-related activities.
  - To make effective recommendations, both U_EK and and P_EK should be well defined and optimized by reflecting recent user sessions of performing the actions and improving the health conditions. That is, U_EK and P_EK should be is optimized correctly by the system.
  - When U_EK is not generic enough for all the users, it will result in less effective recommendation. When P_EK is not well optimized to reflect the results of recent user sessions, the user-specific refinement of U_EK by referring the P_EU will not be effective.
- **Accuracy and Validity of Health Index Measurements**

  The accuracy and validity of the measurements become a factor in determining the effectiveness of recommendations made. Hence, the health index measurements entered from a device or by a user should be checked before being processed.

## 5.2. NFR-2. High Modifiability of the System

The target system has variabilities on several places including the followings.

- **Heterogeneity on Hardware Devices**
  - Adding new *Weight Scale Devices* measuring health indexes
  - Adopting the API of newly added devices
- **List of Health Indexes managed by the system**
  - Adding new health indexes
  - Deleting some of the current health indexes
- **List of Health-relevant activities**
  - Adding new health-relevant activities

- Deleting some of the current health-relevant activities

- **Methods of analyzing the effectiveness of the activities on controlling health indexes**
  - Modifying the Relevance Relationships between Activities and Health Indexes
  - Modifying the Default Values of the Effectiveness

- **Representations of U_EK and P_EK**
  - Representation using a Table
  - Representation using a Graph
  - Representation using a Machine Learning Model

- **Others**

  There can be other types of modifications that can be made to the system.

When a system reveals variability on various variation points, the system should be designed with 'Openness' design techniques. If a target system is development by considering the variability and applying the Openness design of Open-Closed Principle (OCP), the system can efficiently be modified.

# 6. Guidelines for Conducting CEP

## 6.1. Guidelines for Designing the Architecture

Apply the following guidelines for writing CEP Reports.

- **Conformance to the given SRS**

  The submitted AD should conform to the given SRS.

- **Conformance to UML Standards**

  The submitted AD should conform to the notational and usage standards of UML.

- **Consistency among various Artifacts in AD**

  There should be a high consistency among various artifacts (such as diagrams) in the submitted AD.

- **Comprehensibility of Textual Description**

  The textual elaboration of the architecture design should be written in accurate, precise, and condensed way. Hence, the understandability of the AD becomes high. The textual description can be written in English, Korean, or their mixture.

- **Readability of Figures and Tables**

  The figures and tables should be easily readable by applying good formats, right font size and special effects on them. For example, a use case diagram with 100 use cases should be well structured and enlarged if needed.

- **Reasonable Details of Machine Learning design**

  The submitted AD would include a design for managing machine learning models. The description of the machine learning model generation should be written in reasonably details. The description typically includes machine learning algorithms utilized, training sets used, the details for designing the model generation components.

- **Originality of the AD**

  The submitted AD should be an individual work. Any same or highly similar solutions would get a score penalty.

## 6.2. Guidelines for Submitting Reports

Apply the following guidelines for writing CEP Reports.

- **Due Dates for Submission**

  The due dates and times for each CEP report are specified. The CEP reports should be submitted by the due. Late submissions of CEP reports are not accepted.

- **Format of the CEP Report**

  Use the word processor, MS Word, for formatting your CEP reports. Submit the word files, not the PDF files.

- **Submission**

  Submit your CEP report to the course manager, not to the instructor.

## 6.3. Evaluation Form for CEP Reports

The following form is used to evaluate the CEP report.

**Evaluation of CEP Report**

Name: 홍길동

| Criteria | Max | Earned | |
|---|---|---|---|
| Ch.1, Introduction | 2 | | |
| Ch.2, (A1) Architectural Requirement Refinement | 3 | | |
| Ch.3, (A2) System Context Analysis | | | |
| System Boundary Context | 5 | | |
| Functional Context | 5 | | |
| Information Context | 5 | | |
| Behavior Context | 5 | | 25 |
| Ch.4, (A3) Skeleton Architecture Design | | | |
| Justification of Candidate Architecture Styles | 6 | | |
| Integrating Selected Styles into Architecture | 4 | | |
| Ch.5, (A4) Architecture with Views | | | |
| Applying Functional Viewpoint | 7 | | |
| Applying Information Viewpoint | 7 | | |
| Applying Behavior Viewpoint | 7 | | |
| Applying Deployment Viewpoint | 4 | | 35 |
| Ch.6, (A5) Architecture with Quality-driven Design | | | |
| Design for NFR #1, Applying Process | 5 | | |
| Design for NFR #1, Quality Delivered | 10 | | |
| Design for NFR #2, Applying Process | 5 | | |
| Design for NFR #2, Quality Delivered | 10 | | |
| Ch.7, (A6) Architecture Evaluation | | | |
| Intermediate Steps of applying Evaluation | 5 | | |
| Correctness of the Evaluation | 5 | | 40 |
| CEP Score | 100 | | |