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Designing an examinee personal verification system using biometric technology

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Abstract

The examinee personal verification is very important task in every examination. Although many education institutes have information system to support their task, there is no information system to support the examinee personal verification methodology. The main problem of examinee personal verification is how to ensure that the examinee is the right person. This paper presents how to use biometric technology in examinee personal verification by developing the software design model based on IEEE Software Design Descriptions. The main purpose of this paper is to create the software design model for software developers to use as framework to develop the biometric examinee personal verification system for any education institute. Our software design model is based on IEEE Standard for Information Technology—Systems Design— Software Design Descriptions (IEEE-SDD) by presenting twelve different viewpoints.

Keywords**:** *biometric technology, examinee personal verification system, IEEE Systems Design--Software Design Descriptions, Software Model Design,*

1. Introduction

Using biometric technology to verify an examiner has the main propose to ensure a proctor and to reduce the verification process. Developing the biometric examinee personal verification system (BEPVS) to be an efficient software design model, we will need a quality design standard as a framework.

Nowadays many education institutes use information systems for their operation - such as registration systems, schedule management system, back-office systems, etc. The examination is one of the important operations to evaluate the student's knowledge but the trend for information system trend for this operation is to manage examination schedules and to develop online test systems. The examinee verify system is still looked over. The examinee verification method to ensure that the examinee be the right person is still used in traditional way; by checking student documents and signatures to confirm if he or she is present at the examination. The problem is how to proceed further if an examinee loses their documents. How can the proctor decide if person attending is the right examinee? Another problem is how a proctor can verify the real students with photo in their student ID cards if the photo was taken in the past and those cards have not been recently updated. In addition, how can a proctor ensure that ID cards are not counterfeiting.

Biometric Technology is the technology that uses human component to verify or identify individuals by facial recognition, voice recognition, and iris for example. Not only the human organ but biometric technology can also use human behaviors such as motion and key stoke to verify and identify people. At present, security system often use biometric technology for access because of high-rate of confidential information, correctness, convenience, and it is hard to counterfeit. In general education institute use boomer technology in many operations such as check-in/out using fingerprint scan in factories, check-in/out by facial recognition in school. But in the examination verification operation, there is still no education institute using biometric technology for real. Using the biometric technology to verify an examiner has to consider the information system infrastructure of each education institute such as information of the examination and information of the examinee.

Some education institutes have their own information system but, some education institute have no information system and so they need to find the way to create the necessary information in order to use biometric technology to verify an examiner. In addition, biometric technologies have many techniques and types to use. As such, choosing the compatible biometric technique and type depends on the preparation and requirement of each education institute.

Software development for the biometric examinee personal verification system is simple for one education institute, but developing software to use for every education institute is different. We need a clear framework and standard to develop a software design model to be the model for software developers to develop software for each education institute. This paper uses IEEE Standard for Information Technology—Systems Design— Software Design Descriptions (IEEE, 2009), shortly called as IEEE-SDD, as a standard of software design description. The IEEE-SDD shows many design viewpoints, each viewpoint shows various aspects of persons concerned about software development such as user, system analyst, programmer, tester, etc. The BEPVS development also use rapid application development (RAD) as a software development model in order to spend less time developing and meeting the requirement of users more.

2. Objectives

Main objective of this paper is to develop BEPVS design model to be a framework to develop BEPVS software for general education institutes. To develop quality software, the software designers have to use the appropriate software development model. Sarker (Sarker, Faruque, Hossen, & Rahman, 2015)'s research, a survey of software development process models in software engineering, shows the different types of models to develop software including waterfall model, V model, increase model, agile and RAD. Naz (Naz & Khan, 2015)'s paper, rapid applications development techniques: A critical review, explains various of RAD models such as CBD model, RepoGuard, SOA, and etc. Software model design is one part of the software development life cycle (SDLC) process. Bhuvaneswari (Bhuvaneswari & Prabaharan, 2013) shows a survey on software development life cycle models that describes SDLC models.

Valiallah (Valiallah, Seyyed, & Razavi, 2013)'s paper presents Software Architecture Viewpoint Models: A Short Survey, explains various viewpoint of software architecture includung Zachman Framework, Kruchten 4+1, SEI Viewpoints, Garland and Anthony, Rozanski and Woods, The Open Group Architecture Framework (TOGAF), ISO/IEC/IEEE 42010:2011, and Common Architecture Viewpoint Model. Various viewpoint models from Valiallah's survey show the importance of viewpoint model but it cannot identify which model is the best.

To design BEPVS model we have to base on software engineering theories, Hall (Hall & Rapanotti, 2017) presents a design theory for software engineering that describes requirement engineering and problem solving theory to design quality software to solve the problem. Angelov (Angelov, Grefen, & Greefhorst, 2017) presents a framework for analysis and design of software reference architectures.

To develop software design model for BEPVS for any education institute, we have to refer to standard. IEEE Standard for Information Technology—Systems Design— Software Design Descriptions (IEEE-SDD) is a standard to design information system and software that describes point of view for each software development process for the person concerned. IEEE-SDD consists of the twelve viewpoints in the following table:

Table 1 IEEE Systems Design--Software Design Descriptions (SDD) viewpoint

Design Viewpoints	Description Concerns	Example design languages
Context	Systems services and users	IDEF0, UML use case diagram, Structured Analysis context diagram
Composition	Composition and modular assembly of systems in terms of subsystems and (pluggable) components, buy vs. build, reuse of components	Logical: UML package diagram, UML component diagram, Architecture Description
Logical	Static structure (classes, interfaces, and their relationships) Reuse of types and implementations (classes, data types)	Languages, IDEF0, Structure chart, HIPO Physical: UML deployment diagram

Design Viewpoints	Description Concerns	Example design languages
Dependency	Interconnection, sharing, and parameterization	UML class diagram, UML object diagram
Information	Persistent information	UML package diagram and component diagram IDEF1X, entity-relation diagram, UML class diagram
Patterns	Reuse of patterns and available Framework template	UML composite structure diagram
Interface	Service definition, service access	Interface definition languages (IDL), UML component diagram
Structure	Internal constituents and organization of design subjects, components and classes	UML structure diagram, class diagram
Interaction	Object communication, messaging	UML sequence diagram, UML communication diagram
State dynamics	Dynamic state transformation	UML state machine diagram, statechart (Harel's), state transition table (matrix), automata, Petri net
Algorithm	Procedural logic	Decision table, Warnier diagram, JSP, PDL
Resources	Resource utilization	UML Real-time Profile, UML class diagram, UML Object Constraint Language (OCL)

3. Materials and methods

3.1 Information systems in education institutes

Nowadays information communication technology (ICT) has the important role to increase efficiency in general education institutes in term of information management and communication. Simin (Simin, Mojgan, Saedah, & Kalaivani, 2013) reviewed the administration and management of ICT application in many education institutes and found that many education institute use information system in the administration and management of many tasks but not examinee verification task. Electronics school management system (e-SMS) in Macedonia from Majlinda (Majlinda, Bekim, & Mirlinda, 2013) is the information system in school that only focuses on web technology to supports teachers, students and parents to access systems. The examination management system developed by Vasupongayya (Vasupongayya, Noodam, & Kongyong, 2013) focuses on how to manage examinations but does not mention to examinee verification. Shah (Shah, 2014) surveyed the effects of using ICT in education institutes and found many institutes focus on the back-office task management more than examination tasks. Shahmir (Shahmir, Hamidi, Bagherzadeh, & Salimi, 2011) presents role of ICT in the education curriculum, but still doesn't mention examination management tasks. Sergis (Sergis, Sholla, Zervas, & Sampson, 2014) presents supporting school ICT uptake.

Although an examination management system is one kind of information system in education institutes, there are concentrations only on the systems to manage information in the examination while the methodology to verify an examinee is still done by the traditional method such as checking examinee documents or signatures. There is some research into information system to examination management such as Suleiman (Suleiman & Nachandiya1, 2018) which presents the design and implementation of a computer based testing system that incorporates computers into examination task – the examinee verify process uses user names and passwords to access the system, and Singh (Singh &Tiwari, 2016) presents the design and implementation of secured computer based examination system based on B/S Structure which also uses a user name and password to login the system. Fagbola (Fagbola, Adigun, & Oke, 2013) presents Computer-Based Test (CBT) System for University Academic Enterprise Examination that provides a computer-base for the enterprise of examination which concentrates on managing many tasks in the examination but for the examinee verification task still use the old login method is still used. Most research in the field of examination management is focused on electronic examination (e-test) or online-test such as the Secure E-Exam Management System by Castella-

Roca (Castella-Roca, Herrera-Joancomarti, & Dorca-Josa, 2006), which presents how to manage the security for e-learning using cryptographic protocols for the testing process in order to ensure the examinee who have the key, can access the examination and Al-hayek (Al-hayek, et al., 2016) presents E-School – School Management System.

There are many examples of research that provide information system to make examination management more efficiency in many issues, this paper focuses on the ways to reduce human error in the examinee verification process by developing a software design model to be a framework for every education institute.

3.2 Biometric technology

To verify an examinee by using human decision makes it rather difficult to guarantee the right examinee, because of human errors such as bias and negligence might cause mistakes in the examination. Moreover the proctors do not have any tools to ensure against this issue. Using biometric technology is the solution to make the proctor have more confidence in verifying an examinee by using facial scan, fingerprint scan, voice recognition and etc.

There is a lot of research in the biometric technology field that has many different issues. Uddin (Uddin et al., 2011) surveys a variety of biometric techniques including finger print, hand geometry, face, voice and iris. Sruthy (Sruthy, 2013) presents a literature survey on automated person identification techniques that shows various biometric techniques to identify person and also shows the comparison of biometric techniques in various ways. Jain (Jain, Nandakumar, & Ross, A. (2016) presents 50 years of biometric research: accomplishments, challenges, and opportunities that show the evaluation of biometric techniques over the last 50 years.

The big question in applying biometric technology in any task is what the best biometric might be. Prabhakar (Prabhakar, Pankanti, & Jain, 2003) presents the comparison of several biometric technologies that can answer the previous question that there is no best biometric, each has both strong and weak points. The application of biometric technology to any task has to consider the character of the task. Biometric technology also depends on availability of hardware to collect the biometric information such as digital camera, finger print scanner, microphone for voice recording and other biometric device.

Using biometric technology to verify an examinee in BEPVS model does not specify the biometric techniques. That mean BEPVS model can support any type of biometric depending on the requirement of each education institute. The most compatible biometric technique to verify the examinee should be the general basic biometric such as face and voice recognition because of their ease of use and the devices needed are not too expensive for education institutes.

3.2.1 Face recognition

Face recognition is the most famous method used in identifying or verifying person. It consists of three main issues including face detection, feature extraction and face matching.

Garg (Garg, & Sharma, 2012) focuses on face recognition techniques and presents three different approaches on how to design a face recognition system including feature extraction method, holistic extraction method, and the eigenface method. Fathy (Fathy, Patel, & Chellappa,, 2015) presents face-based active authentication on mobile devices that uses Viola (Viola & Jones, 2004) robust real-time face detection technique to identify person on iPhone. Al-Maadeed (Al-Maadeed, Bourif, Bouridane, & Jiang, 2016) presents low-quality facial biometric verification via dictionary-based random pooling.

3.2.2 Finger print recognition

Finger print recognition is very strongly identified and verified biometric technique. It relies on hardware to collect and scan finger print data. Each finger print recognition technique has different type of finger print data. Suman (Suman & Kaur, 2012) research presents the survey of offline finger print verification system that show the methodology and processes of using finger print biometric to identify person, and shows how part of finger print data can be divided into arch, loop and whorl. The finger print recognition from Suman's paper is explained three main processes which include preprocessing process, post processing and finger print verification process. Arjona (Arjona & Baturone, 2012) presents model based design for selecting fingerprint recognition algorithms for embedded systems.

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3.2.3 Multi-biometric

Sometimes, using a single biometric technology is inadequate and the multi-biometric methodologies are applied to verify or identify persons instead. Lumini (Lumini & Nanni, 2017) presents a new model to increase the accuracy in a combination of biometric matchers to increase precision rate. Shah (Shah & Haradi, 2016) presents the implementing biometrics on Raspberry Pi by using two types of biometric including finger print and face to verify a person. Arigbabu (Arigbabu, Ahmad, Adnan, & Yussof, 2015) presents Integration of multiple soft biometrics for human identification by merging the various face features such as shape, skin colour, height and weight of face together in order to make identification more efficient.

3.2.4 Behaviour recognition

Behaviour recognition is a new trend in biometric technology by using human behaviour to identify or detect person such as motion, key stoke, and etc. Alzubaidi (Alzubaidi & Kalita, 2016) presents authentication of smartphone users using behavioural biometrics to show the various human behaviour detection methods to access smartphones. Mahfouz (Mahfouz, Mahmoud, & Eldin, 2017) also presents a survey on behavioural biometric authentication on smartphones. Lopez-Garcia (Lopez-Garcia, Ramos-Lara, Miguel-Hurtado, & Canto-Navarro, 2014) presents using signature to verify person.

From related work, although there are a lot of researches of biometric technology, the purpose of his paper does not focus on the biometric techniques but aims at the way to apply any biometric into BEPVS model.

4. Results

Due to the traditional methodology for examinee verification unable to ensure that the examinee being the right person or not, this paper presents the concept to apply biometric technology to ensure the proctor to verify an examinee instead. Our approach is not only concerned about the using biometric technology in examinee verification but also considers the component that connects with the information in examination management. This section presents two BEPVS models consist a conceptual framework to show the components of BEPVS and a revised BEPVS model to deeply identify each component of BEPVS. Our BEPVS conceptual framework by Sethapong (Wong-In & Netinant 2016), consists of six components as show in Figure 1, is developed by presenting general tasks in general education institutes and focusing on the task that concerns about the examination. In horizon axis presents physical device issue while vertical axis presents methodology issue.

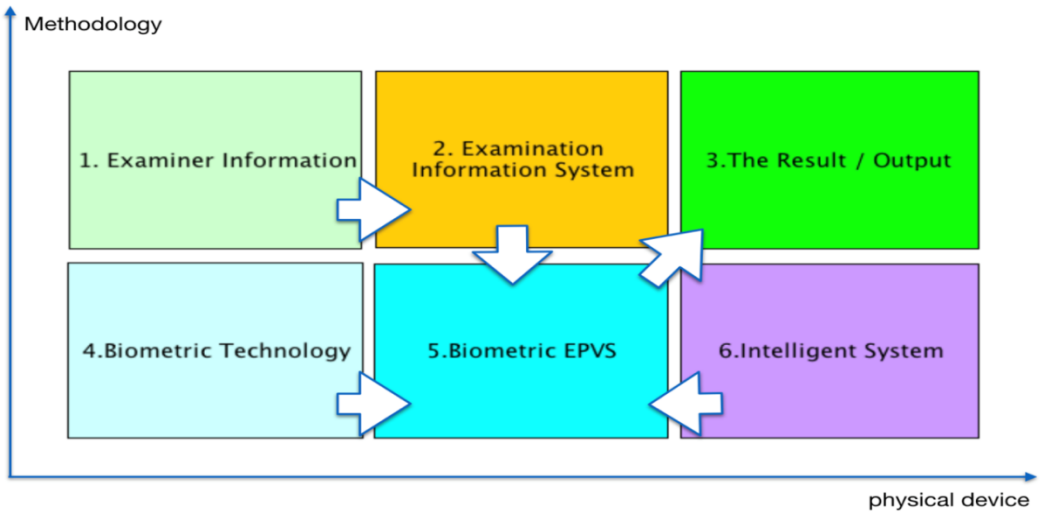

Figure 1 BEPVS Conceptual Framework includes (1) Examinee Information focuses on the information of examinee and the methodology to collect. (2) Examination Information System is about the system to manage information of examination. (3) Result/Output component describes the output from verification system. (4) Biometric Technology focuses on biometric technology that applies in the system. (5) Biometric EVPS explains about the methodology to

apply the biometric into the examinee verify system. (6) Intelligent System component focuses on the new solution or new technology to use in examinee verify system such as new smart device, new CCTV, and working with new biometric device in the future.

To revise BEPVS conceptual framework by Sethapong (Wong-In & Netinant 2017), as shown in Figure 1, the revised framework of BEPVS presents the design model in terms of the context design viewpoint. Our concerns are the system services, structure design viewpoint, internal constituents, and organization of design subjects of the system. This revised framework also presents some piece of the interaction design viewpoints that concern about the communication between components. The revised BEPVS can be divided into thirteen components as shown in Figure 2.

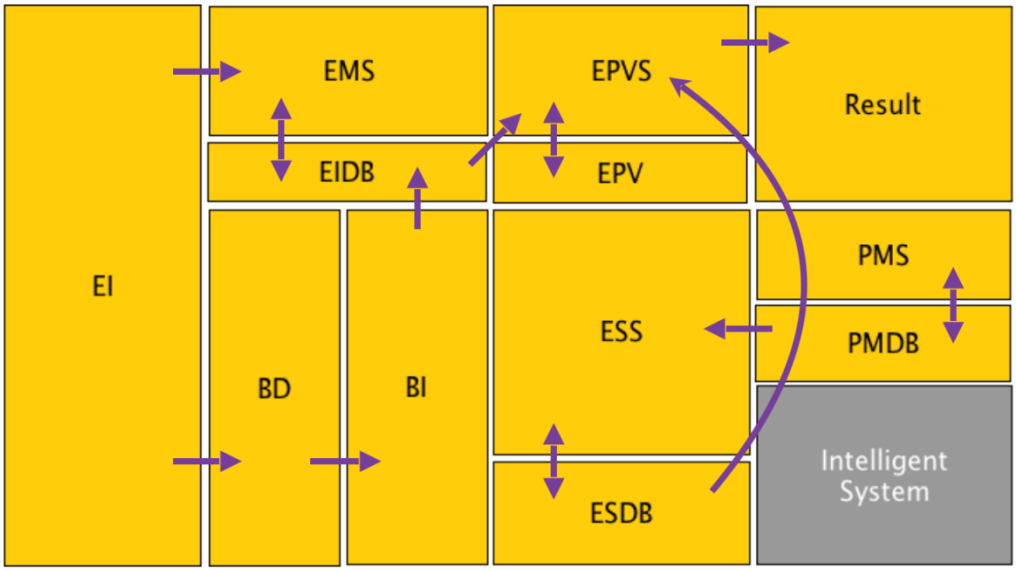

Figure 2 Revised BEPVS model

From the revised BEPVS diagram in Figure 2, it shows the BEPVS revised framework can be divided into thirteen components. This revised framework begins with Examinee Information (EI) component containing the examinee information to use in the system and methodology to collect the examinee information. There are two types of examinee's information be used in our model. The first type is basic information such as prefix, first name, last name, gender, examinee id, etc., which will be provided by Examinee Management System (EMS) component. The second type is biometric information, such as fingerprint, facial image, iris voice, palm, etc., which can be collected via biometric device which provide by Biometric Device (BD) component. The BD component describes the biometric device that used in the system such as fingerprint scanner for examinee fingerprint, digital camera for examinees facial image, etc. The Biometric Information (BI) component from BD is similar to EI which explains examinees information in term of basic information. BI explains examinee information in term of biometric information. If some education institutes have only basic information of examinee they can develop only BD component to collect complete examinee information for BEPVS. Both EI and BI are stored in EIDB. The essential information for examination is the examination schedule that provides in Examinee Schedule System (ESS) component. ESS focuses on how to manage the examination schedule, such as examination room, and examination schedule. Examination schedule Information will be stored in Examination Schedule Database (ESDB) component. Proctor Management System (PMS)

component is the system that manages proctors. Some education institutes hire external proctors, so PMS is needed to manage their information and store proctor information in the Proctor Management Database (PMDB) component. To verify examinee using BEPVS, Examinee Personal Verification System (EPVS) component will prepare basic information including examination schedule from ESSDB and examinee list from EIDB. Before the examinees access the examination room, the proctor will use biometric device to verify the biometric information of each examinee and send it to the Examinee Personal Verification (EPV) component. The EPV component could be implemented on cloud systems (Pukdesree, & Netinant, 2016). Our model could make the system possible to adaptive system (Netinant, 2015) and the system can be implemented on mobile devices. EPV of each system may have different methodology to extract biometric information. However, it depends on the appropriateness of each education institute. EPV will verify each examinee's biometric information and send back the result to EPVS component. Then EPVS will collect the result, summarize and then send it to Result component. For the Intelligent System component that is concerned with the way to bring the intelligent system into BEPVS such as using smart devices, artificial intelligent (AI) and other new technology in the future.

The result of examinee verification is the output from BEPVS in various formats which depend on each education institutes' requirements. In order to define the result format for BEPVS, some education institute define the result by setting the question such as how many absent examinee - in percentage, how many fraud, who is the proctor. We can describe the revised BPEVS model in mathematic term as following format.

R = set of the answer for question, we focus on how to establish questions for examinees verification.

S = set of systems, focus on services of each system.

D = set of databases, focus on location and what kind of database for storage the data.

I = set of information, focus on the schema of each information.

M = set of methods, focus on process or algorithm of each method.

We can describe revised-BEPVS framework in mathematic form the following.

$\forall BEPVS \rightarrow \{EI, BI \in I\} \cup \{EMS, ESS, PMS, EPVS \in S\} \cup \{EIDB, ESDB, PMDB \in D\} \cup \{EPV, BD \in M\} \cup \{Result \in R\}$

The Result component is contained with many questions in the examinee verification such as how many the absent examinees, how much the failure verification and who is the proctor. To answer the question we have to concern the other component as below.

$Result \in R \rightarrow (\forall EPVS, EPVS \in (EPV \cup ESDB \cup (EIDB, EIDB \in BI \cup EI)))$

We also describe systems in term of Maths following below.

$\forall EMS$, EMS= {insert examinee information, update examinee information, delete examinee information}

$\forall PMS$, PMS= {insert proctor information, update proctor information, delete proctor information}

$\forall ESS$, ESS= {create examination: assign date, assign location, assign examinees, assign proctor}

$\forall EPVS$, EPVS= {view examination schedule, view examinee list, verify examinee}

We can explain database issue in BEPVS model as following.

$\forall EIDB$, $\forall ESDB$, $\forall PMDB \in$ {Server name, Database name, Connectivity}

I is set of information, we can describe information for each information component as following.

$\forall EI$, EI $\in$ {examinee: id as string, first name as string, last name as string, gender as integer}

∀BI, BI ∈ {examinee: id as string, biometric information as specific format, last update as timestamp}

For set M, EPV and BD, we can describe

∀EPV ∈ {type of biometric, preprocess algorithm, exacting algorithm, matching algorithm}

∀BD ∈ {type of biometric, preprocess algorithm, exacting algorithm, device connectivity}

To design the BEPVS model by using IEEE Standard for Information Technology—Systems Design— Software Design Descriptions (IEEE-SDD), this paper develops the design model by referring to different IEEE-SDD viewpoints to clearly represent the various roles of software developer.

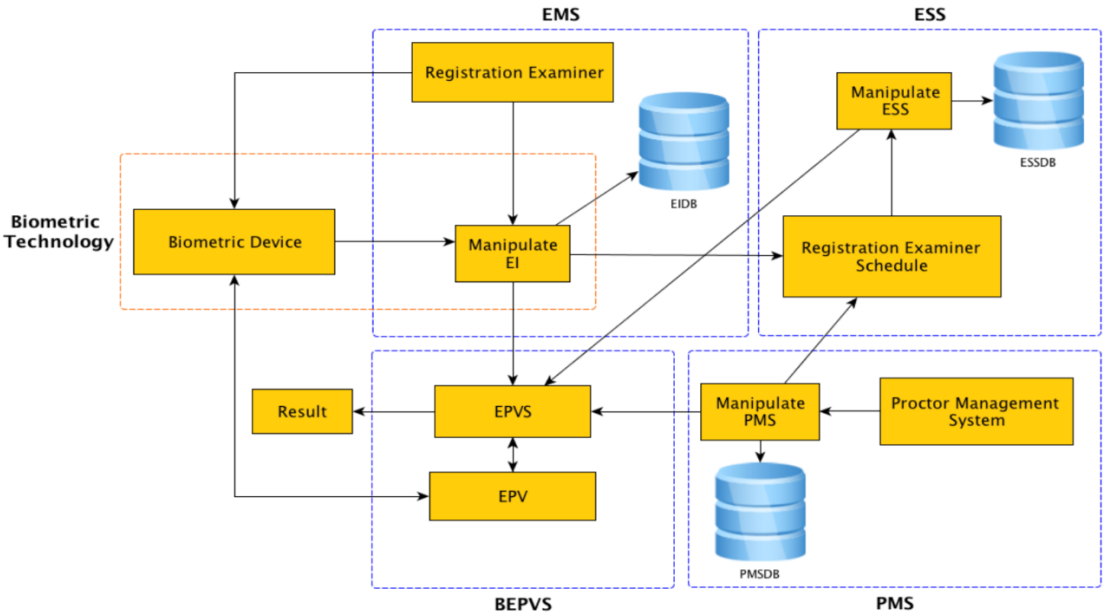

Figure 3 Dependency viewpoint presents the viewpoint which specifies the relationships of interconnection and access among entities. This viewpoint provides an overall picture of the design subject in order to assess the impact of requirements or design changes. It can help maintainers to isolate entities in case of system failures or resource bottlenecks. It can aid in producing the system integration plan by identifying the entities that are needed by other entities and that must be developed first. This viewpoint can also be used in integration testing for software testers.

5. BEPVS design model based on IEEE standard for software design

Figure 3 presents the dependency viewpoint, one of various designed viewpoint based on IEEE-SDD. It is only a sample diagram of software design by using BEPVS model.

For example, the Figure 3 presents the dependency viewpoint and Figure 4 presents the interface viewpoint of BEPVS. Our design can prove that BEPVS model can work well and support the adaptation. We have develop BEPVS prototype as shown in Figure 4.

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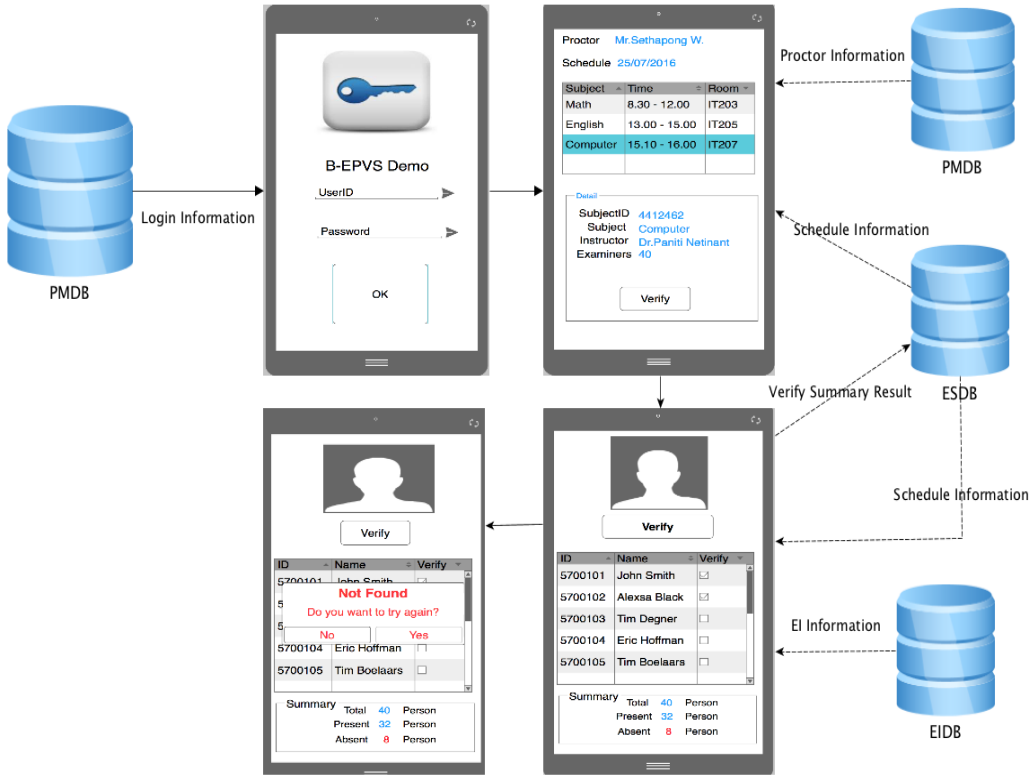

Figure 4 presents the interface viewpoint of BEPVS including software interface, database and connections.

Figure 4 shows the interface viewpoint that helps both user and developer to clearly see the final output of BEPVS software before begin the coding process.

6. Evaluation of BEPVS design model

BEPVS is a software design model based on IEEE software design description standard. In order to evaluate BEPVS model can do in two ways consist empirical and refer to standard. For the first way we should apply BEPVS design model to develop software to verify examinee for some education institute to evaluate the efficiency of software. The second way, we can evaluate software design model qualities by referring to standard. This paper focus on software design, so we compare some of BEPVS design model with the viewpoint of IEEE design description standard as shown in table 2.

Table 2 Comparison BEPVS design model with IEEE Systems Design--Software Design Descriptions (SDD) viewpoint

Figure	Design Concerns	Design Viewpoints
Figure 3	System overview, Sub-system Flow of Data, Database location, System components	Context, Dependency, Interaction
Figure 4	User interface, Database, User work flow,	Interface, State dynamics

Table 2 presents sample of diagram that design by using revised BEPVS model and can be presented in Figure 3 and Figure 4 based on the IEEE design description standard.

7. Conclusion

This paper presents a new software design model for using biometric technology to verify an examinee in order to ensure the examinee is the right person and to reduce human error (proctor's decision). This paper does not focus on finding the best way to apply biometric technology but concentrate on the way to use any biometric technology to work in BEPVS. The BEPVS design model is expected to be used to develop BEPVS in any education institute with various types. For this reason, we have to create the design model with standards for various software developers to clearly understand. The BEPVS design model development is based on IEEE-SDD standard by representing twelve viewpoints for different purposes of use.

8. Future work

BEPVS design model in this paper just present a few viewpoint from thirteen viewpoints to be samples for software developers to prove that this model can be designed in IEEE standard viewpoint. The future work is to implement BEPVS to any education institutes with different requirement to prove that BEPVS model can apply to any education institutes.

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