# A Hospital Based Dynamic Platform Workflow Management

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***Abstract*—In this paper, we propose the use of dynamic compilation of web services to support workflow management in a hospital setting. Web services related to work practices belong to an organization that have been designed, built and stored in a web services repository. These web services can be shared with multiple functional units within the organization via the intranet or the Internet. The workflow of a health scenario will be presented. Work practice services that were selected will be compiled logically and optimally using the proposed dynamic compilation platform. The final outcome is presented as a web application. The web application can be compiled and recompiled as often as needed whenever changes to the requirements occur. This dynamic platform for workflow management (DPWFM) integrates the decision making process of workflow management for each functional unit in the organization to customize the workflow requirements that suits their needs.**

***Index Terms*—Workflow Management System, Web Services, Work Practices.**

## I. Introduction

Since the early part of last century, we have witnessed progress of modern manufacturing facilities that can mass-produce and deliver products to mass audiences in an unprecedented manner and speed. Although this progress can be attributed to the development of telecommunication and advanced intelligent information technologies, developing an optimal working environment and managing the required amount of work in an efficient manner are still pose major challenge for businesses organization. This is largely due to the unstructured and unpredictable nature of demand and supply [3]. Workflow Management (WFM) [9] or Business Process Management (BPM) [17] has attached a lot of attentions due to the need to improve business process as well as productivity in many organizations. Managing the amount of work flowing through the work force and allowing people to work in an optimal environment to producing maximum output is increasingly important in businesses today [14].

Recently, organizations have been using expensive tools or sophisticated software to organize workflows. Most of these tools are difficult to use and often cannot meet the specific requirements of a specific organization [3]. In addition, it is generally very difficult to modify or change decision-making rules and procedures in these software, and the cost of maintenance can also be very high [15].

In this paper, we propose the use of a dynamic compilation of web services to support workflow management (DPWFM). In the proposed DPWFM design, web services related to work practices of an organization are designed, built and stored in a web services repository [2], using current industry standard tools and techniques such as IBM's SNOBASE [1], Java 2 Platform, Enterprise Edition (J2EE) for developing Model Driven Architecture (MDA) [20], Business Process Execution Language (BPEL) [13][16]. Furthermore, these web services can be shared with multiple functional units within the organization via the intranet or the Internet. Information related to each work practice service will be published from the server that houses the web services repository and users are able to select the work practice services required via a custom-built web interface. Selected work practice services are compiled logically and optimally using the proposed dynamic compilation platform. The final outcome is presented as a web application, which can be compiled and recompiled as often as needed or whenever work practice requirements change. Confidentiality and security have been designed and incorporated into the final web application.

We have chosen to demonstrate the advantages of DPWFM in the domain of healthcare, as it is one of the most demanding and yet critical business processes. The importance of good workflow management in the healthcare sector has prompted the Australian healthcare sector to look for better developed information systems [10]. According to CRN Australia [12], the South Australian Government has committed to spend $17 million in helping to improve information systems and business process management for the healthcare sector.

The rest of the paper is organized as follows. In section II, we present background of business activities. Sections III and IV describe the hospital scenario, and the proposed conceptual model of DPWFM. The development environment will be discussed in section V, and section VI concludes the paper.

## II. Business Background

A business process is a series of business activities describing how organizations produce and deliver special services to users, customers, or markets [11]. Management, operations and supporting processes are three major logical components that serve to plan and control workflows of business activities in an organization, as well as to support different workflows that work together.

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WFM is the way to manage the flow of activities or events, which then pass to appropriate partners to produce the required products or services. It is an effective way of decreasing risks of costly amendments, time delays, insufficient resources and human errors. However, traditional WFM concepts are difficult to implement without the assistance of information technologies [5]. Hence, 'WFM system' is a system that defines, creates and controls a workflow by running it through a workflow engine. It consists of a process design, a system configuration and a process enactment [8].

In the case of a hospital, better workflow customization can facilitate easy documentation of reiterated work processes, and at the same time reduce work redundancy and stress levels of nursing staff. Reiner *et al* [14] show that using workflow optimization in a radiology department can reduce time-consuming steps and reduce workloads. Their results showed that productivity has increased and error rates have reduced.

## III. Hospital Scenario

Generally, different hospitals have different patient care procedures in their workflow processes. However, the majority of information flow and the communication media remain quite the same. Nursing care usually involved face-to-face and paper-based communication. Fig. 1 shows an illustrated workflow sample of nursing care in a ward. First, when a doctor diagnoses a patient as shown in step 1, he writes his orders in a handwriting form on the paper worksheet (called "handover sheet" or "chart") and that will be clipped on a clipboard, which is usually placed at each patient's bedside. The doctor orders including his diagnosis, the drugs required for the patient, and treatment plan. The doctor then passes the orders to an in-charge nurse (a nurse supervisor). Then the in-charge nurse organizes the nursing care schedule based on the doctor's orders. The original orders from the doctor may need to be divided into multiple separate tasks/functions to be allocated to individual medical nurses through using the handover sheets as shown in step 2.

The in-charge nurse has the responsibility to manage the schedule for nursing care of each patient in accordance to the doctor orders. They are also required to liaise between nursing staff (medical nurses) and nursing managers (in-charge nurses) in different shifts, and to create spirit of collaboration between them. The in-charge nurses also assign tasks or functions to each medical nurse in her ward as shown in step 3. After the medical nurses receive the orders from the in-charge nurse, they take care of their respective patients as shown in step 4. Medical nurses will record all vital signs such as weight, blood pressure, respiration rate, body temperature, and write them by hand in the patient's report, which is attached with the same chart as the doctor's orders. Subsequently, that patient's report will be passed to the nurses in the next shift of work.

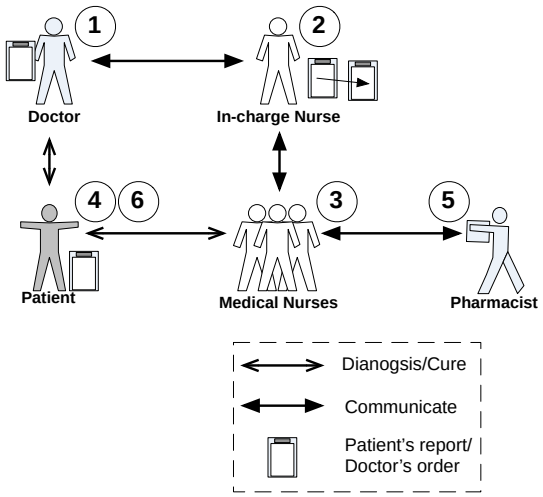


**Fig. 1. Workflow in nursing care**

During each nurse shift, pharmacists may have to dispense drugs to the medical nurses for each patient according to the in-charge order chart as shown in step 5, which is usually hand-written by the nurses. Finally, the medical nurses provide medicines for each patient in the frequency as rearranged by the in-charge nurse in step 6.

Once a day shift is finished, the nurses who work in the afternoon shift will care for the patients in the ward. Information about the patients from the nurses in the day shift will be transferred to the nurse in the afternoon shift via the nursing office. The workflow will be repeated once again for the night shift, which will then hand over the patients' reports to the following day-shift nurses. This process is repeated every day.

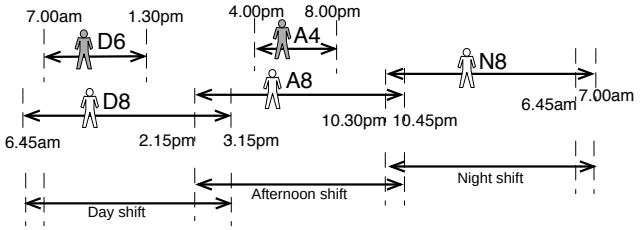


**Fig. 2. Work shifts of Australian nursing care (based on low care)**

Fig. 2 illustrates an example of Australian nursing shift scenario of low care hospital ward in New South Wales. There are three shifts per day, a day shift, an afternoon shift, and a night shift. The main shift is eight hours long and the supported shifts or sometime referred to, as the short shifts are six hours for day shift and four hours for night shift. As shown in Fig. 2, D8 is an eight-hours day shift; D6 is a six-hours day shift; A8 and A4 are represented eight-hours and four-hours afternoon shifts, while N8 is an eight-hours night shift.

In the low care hospital ward, there are at least one nurse on duty for in the eight-hours shift and another nurse on the short shift. The staff of D8 or A8 is generally the in-charge nurse that is scheduled to work with the staff in the short shifts. In high care hospital ward, the number of nurses will increased in accordance with the number of patients in the ward. For example, one nurse can take care of four patients. So, if there are eight patients, two nurses should be allocated. However, if there are nine patients, one extra short shift nurse should be added, which results in three

nurses in a shift, to prevent overload.

The mean of communications in the nursing care workflow is generally paper-based media: doctor passes orders to the in-charge nurse, in-charge nurse organizes tasks for each medical nurse, medical nurses obtain drugs from the pharmacists; all transactions involve papers (see Fig. 3). The longer shift staff is responsible to monitor the tasks carry out by the short shift nurse during an overlap shift. Handover sheets will be used to transfer patient's information to the nurses in the following shift during the handover meeting. Generally, there are two common form of communication used in the hospital ward, talking face-to-face and reporting on handover sheets. Most nurses are comfortable with these forms of communications in the hectic and stressful working time.

However, reading hand-written notes correctly is important to ensure accuracy. Inaccurate interpretation of texts in the handover sheets can lead to missing or incorrect information, and at best cause delays until information is crosschecked with the doctor.

It is undeniable that nursing routine needs to be error-free and efficient in order to diagnose and treat patients successfully. In order to do this, communication and information flow between the different actors in a ward need to be reliable, accurate and systematically controlled. This control has to be applied by a member of the hospital staff or an automatic executor.

However, the additional requirement for medical staff to work more carefully and precisely is likely to increase the amount of stress and consequently the number of mistakes make [7]. For example, mistakes can occur in the transactions between medical nurses within each shift, or in the information flow between the shifts. Eley *et al* [7] show that the existing computer system could not fit to the nurses' demands. More than 60 percents of their respondents show that additional requirements added too many works to them.

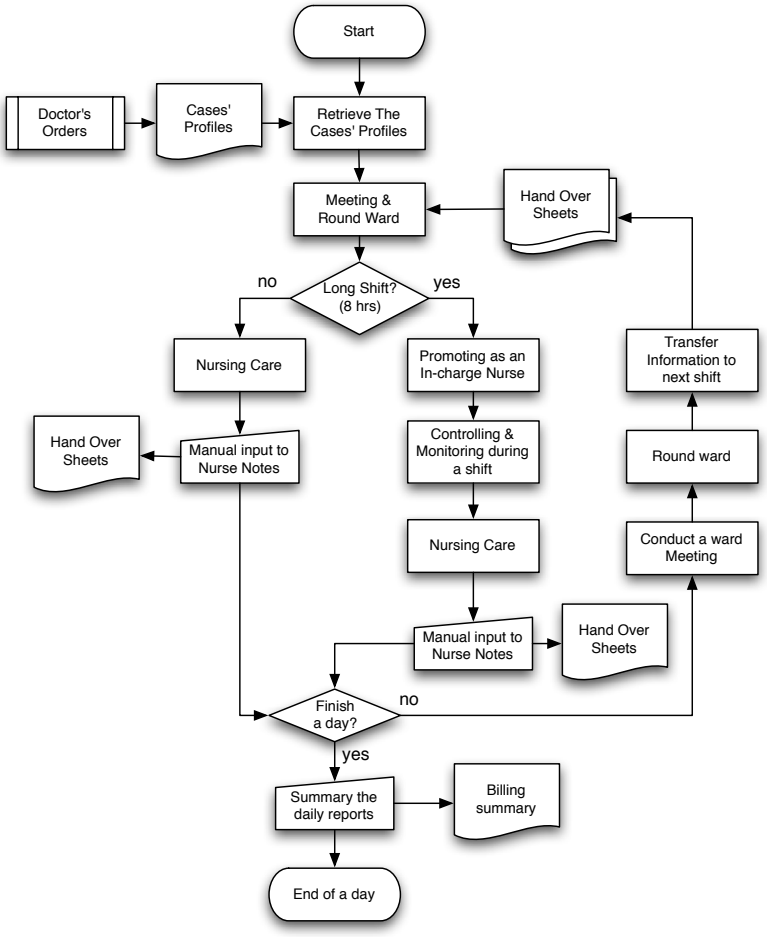


**Fig. 3. Workflow of Australian nurses (based on low care)**

In the remainder of the paper, we proposed the uses of dynamic compilation of web services that support workflow management. It is a user-oriented design, which users can customize their services' demands. The following section IV provides the descriptions of the structure used in the dynamic platform for workflow management (DPWFM), and section V describe the implementation process.

## IV. Proposed Conceptual Model of DPWFM

To develop the Dynamic Platform for Workflow Management (DPWFM), we propose to use dynamic compilation of web services. In this case, a workflow web application is a compilation of web services selected from a web services repository. All the web services developments will be done using current industry standard tools and techniques such as BPEL [13], MDA [20], Service Oriented Architecture (SOA) and IBM's SNOBASE [1]. Most of

these web services are reusable [4]. The workflow web applications are designed to characterize the business processes or the tasks that the employees need to carry out within an organization. Selecting the web services related to the work specifications of an employee are based on the criteria of the supervisor/manager, job descriptions, process enactments, and the requirements to link to any real-time processes.

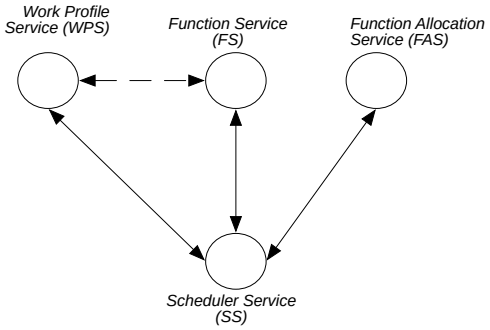


**Fig. 4. DPWFM architecture**

Fig. 4 shows the DPWFM architecture of *Function Service (FS)*, which analyzes and manages web services. FS provides web service descriptions and communicates information to Universal Description, Discovery, and Integration (UDDI). FS collects functions and sub-functions, which are the collections of tasks for each complete function. For example, the function service 'writing report' for patient 'A', may consists of four or five sub-tasks such as 'recording vital signs of the patient', 'fill-in dose of drug', 'fill-in frequency of drug provided', or 'special requirements'. These sub-tasks can be modified and reused again in other function services.

The next module, job descriptions of the staff are stored and described in a *Work Profile Service (WPS)*. It includes career positions, main responsibilities, routine tasks, minor tasks, extra tasks, and ad hoc tasks. Supervisors/managers will determine which FSs are suitable for each employee. Generally, one staff can have more than one job function in a ward; one general nurse is also 'a medical nurse'. At the same time, she can be assigned as 'an in-charge nurse' for a particular shift. WPS can also be used to describe special projects, major and minor responsibilities.

In a *Function Allocation Service (FAS)*, the DPWFM gathers decisions of supervisors. Simple user-interface is used to allow supervisors/managers to assign specific tasks to each employee, for example by simply using the checkboxes when selecting their prefer FSs. FAS handles the electronic scheduling tasks, customise suitable tasks for each staff, and this can reduce confusion in interpretation of the tasks assigned to individual nurse.

Templates can be designed and used for routine assignments, which provide standard sets of web services and work specifications. Supervisors/managers of each functional unit can take full control in customizing the workflow schedules and the deliverables require for each of their subordinates. In addition, FAS can also allow changes and modifications upon the supervisor's requests. This will provide more flexibility and better control in organizing work schedules in the function unit.

The *Scheduler Service (SS)* will perform as follows:

1) SS first carries out the matching function between FS and FAS with WPS, then
2) SS will cross check information with WPS for assigning a matched FS to a designated employee, then
3) SS will perform a dynamic compilation of all the selected web services from FS into a web application, which will schedule all the selected business processes in a logical and well-scheduled order for the designed employee.
4) During the compilation, SS is capable of calculating the best schedule based on real-time requirements from FASs.
5) SS can also allow tasks/activities be enabled or disabled using either automatic setting or custom setting during compilation

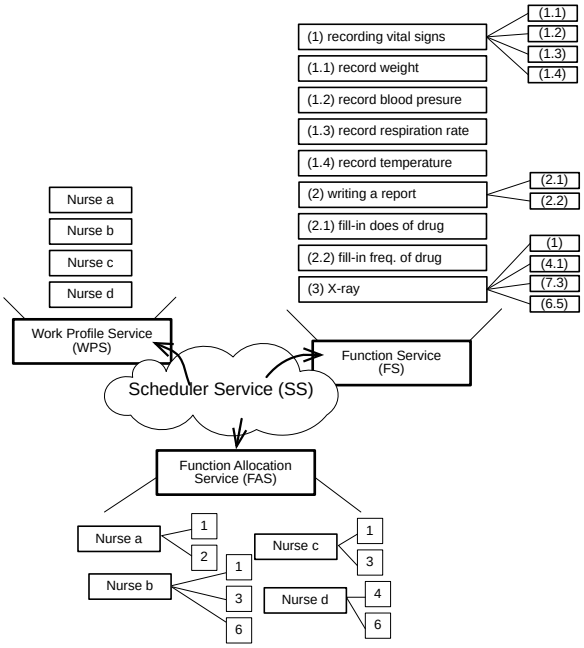


**Fig. 5. Optimal services management**

Fig. 5 shows the functional relation of the service elements between WPS, FS, and FAS. First, WPS contains all potential job descriptions in an organization such as 'doctor', 'nurse', 'in-charge nurse', 'medical nurse', and 'pharmacist'. Second, WPS contains all profiles of all workers such as 'work qualifications', 'work experiences' and so on. Third, FS contains all required web services, which define all business processes and the function tasks that use in all functional departments. For example: '(1) recording vital signs' is a FS which consist four sub FSs of '(1.1) record weight', '(1.2) record blood pressure', '(1.3) record respiration rate' and '(1.4) record temperature' and these can be work as sub-FS.

These web services were designed to comply with the organization work practices requirements during the design-build-store process. Finally, FAS contains the desire job functions that allocate to every individual medical nurse in the organization. At run-time, nurse supervisors in each ward or department can assign new tasks or modify previous assignments whenever it is necessary. The system will recompile the changes into the best schedule based on working functions required and provide the newly arranged customizes tasks to the staff.

## V. Development Environment

The DPWFM is designed to dynamically compile workflow web applications over the Intranet or Internet. The development is centered on using open source resources to enable seamless communication with any operating platforms. End users can use difference operation platforms in difference functional departments.

The DPWFM uses standard XML to incorporate web services and to retrieve information intelligently. The retrieval services can interpret XML information from any operating platform

### *A. Web Services Development*

The purpose of developing the DPWFM using web services technology is to provide a standard platform for interoperability among difference software and applications. In addition, web services are best suited to work across multiple platforms [18] that aid to avoid investment costs of changing infrastructure. In this project, web services development will be using the current industry standard tools and techniques. Most of these tools and techniques are available as open source and can be used freely for development. The major requirements from any organizations are to design business logics that can be implemented in the web services to facilitating business functions.

In general, communication between different platforms requires more resources especially when using complex software applications. Due to limited resources, budgetary constraints, and high investment cost, it is less likely that an existing organization will be able to replace their operating environment easily and frequently. There are also numerous difficulties encountered in transferring information from one platform to another. Unusual tasks can lead to possible human errors when employees face with some duplicated steps or jobs. In this case, the DPWFM will perform comprehensive database operations by compiling dynamically into workflow web application. Information on the application will be displayed in XML/HTML format. As a result, the DPWFM will facilitate better communication in the whole organization and particularly the communication between management of each functional department and their employees or users.

Our dynamic platform is to use the Apache as the web server, MySQL as the database server, PHP, and AJAX as web design languages. The implementation will try to utilize the current hardware resource of the organization by incorporating open source information technologies.

### *B. Features of Dynamic Platform*

DPWFM platform allows the cooperation of human decision-making combined with the use of information and communication technologies to dynamically compile optimized workflow solutions. According to Deng [6], business process was divided into dynamic, adaptive and flexible processes depending on the aspects of workflow. DPWFM has the advantages of adapting web services dynamically and allow human decision to manipulate and customize any levels of details related to the business process specifications. It is designed to be more flexible and simple to manage, control, monitor, and use.

The workflow web application, compiled by the DPWFM, provides the facilities to tailor for individual operating requirements and to allow customization of web user-interface that will cater for different skill levels of employees and users. In addition, it uses different templates to standardize on consistent user interface and work specifications. This will greatly reduce the necessity for excessive training.

Generally, the organizations use drop-in sessions to answer users questions related to the usage of the workflow web applications compiled from the DPWFM. Due to the fact that, every workflow web applications compiled from the DPWFM are either on an Intranet or the Internet, users can access their applications anywhere and anytime as long as their computers are connected to the Internet.

#### *1) User Management*

The DPWFM classifies users into three basic categories based on their usages, security clearance levels, and functional tasks in the organization. The first category is the administration staff that initial installs, configures, supports and maintains the DPWFM system. The second category is a supervisor, manager, head of unit or department, and IT support staff of the department. Their responsibilities are to manage the flow of business functions, assign tasks, control information and accessibility of the system for each employee. Finally, the third category is the end-users.

User management policy of the DPWFM is designed to incorporate any security measure to protect private information and assignment of security clearance to any users. The goals of the DPWFM are to help end-users to work faster with more efficient and make less error as compared to the traditional ad-hoc workflow arrangements.

#### *2) Interface Design*

The DPWFM aims to design the friendly user interface to all users. The more ease of uses of the system, the more efficiency improving job performances [19]. The nurse supervisor can allocate the function services (tasks) to each medical nurse by selecting the graphically display system report that provide function service and work profile services. The user interface design will incorporate simple widgets, such as checkbox, drop-down list, into the nurse supervisor web pages. The nurse supervisor can pick and choose any function services that he/she wanted to allocate to each individual staff.

Fig. 6 shows an example of user interface designed for the nurse supervisor. The system presents the related function services to the nurse supervisor. After the services have been selected, the system will recompile and customize those allocated function services to each medical nurse. Fig. 7 shows the user interface for a medical nurse (A). The interface of nurse (A) shows the set of daily tasks. The tasks can be expanded to show details. Each medical nurse receives a slightly different work schedule based on the urgency of the assignments and any additional requirements given by the nurse supervisor.

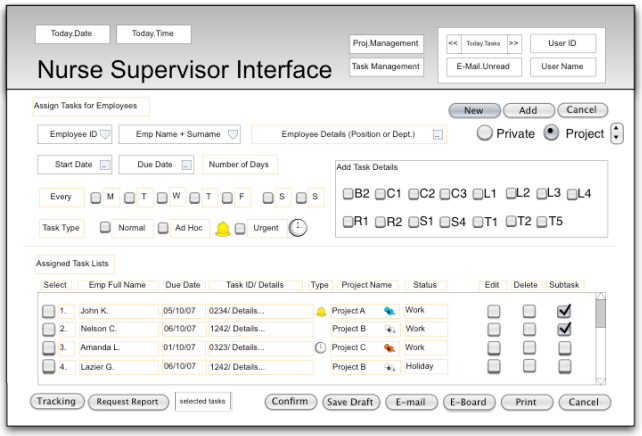


**Fig. 6. The interface design of nurse supervisor**

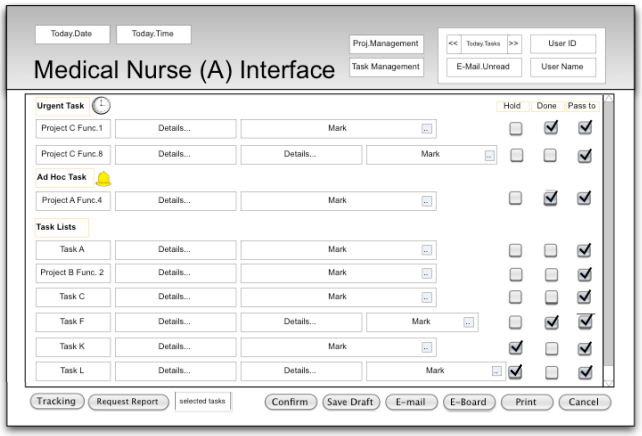


**Fig. 7. The interface design of nurse staff**

In term of security measures, each employee is assigned with a security clearance level whenever the workflow web application is compiled. Supervisors or managers can alter the security clearance level based on the requirements of the final business process web application. The security measures allow employees to complete their assigned responsibilities and at the same instance, it provides necessary protections to ensure the integrity of the overall system. Supervisors can use DPWFM to monitor the performances of employees by tracking the progress of their workflow assignments. Any information collected in the DPWFM application can be tracked by using the updated, the changed data logs and the history logs.

DPWFM has integrated the decision-making processes of BPM with information technologies, and provided facilities to each functional unit of an organization that suits users' needs. Users are allowed to access, to control, and to customize their workflow requirements that complied for each organization standard and policies.

The environment for workflow web application interacting with the users is illustrated in Fig. 8. The dynamic compilations are carried out as the back-end operations. In the front-end, users or staff can complete their workflow requirements by interacting with their respective DPWFM web applications.

As shown in Fig. 8, DPBPM consists of three layers, the data layer, the business layer, and the presentation layer.

The data layer consists of database servers using in the existing system. Some departments may be using different database servers from different vendors and DPBPM does not require organization to change their existing database systems. DPBPM will perform information exchange with those database servers in the form of XML. Information received from database servers will be processed and presented to users who are using the system.

The business layer consists of business logic that encompassed BPM will be integrated through using SOA. The Service Schedule (SS) will select, compute and determine the sequences of the tasks at hand and will be compiled or recompile using the WPS and FS according to the individual setting in FAS. Based on the business logics, the suitable work schedule for everyday jobs will be generated for the workers and presented as a web application. The workers can then follow their work schedule in the proper jobs sequence to complete the work assigned by their superior.

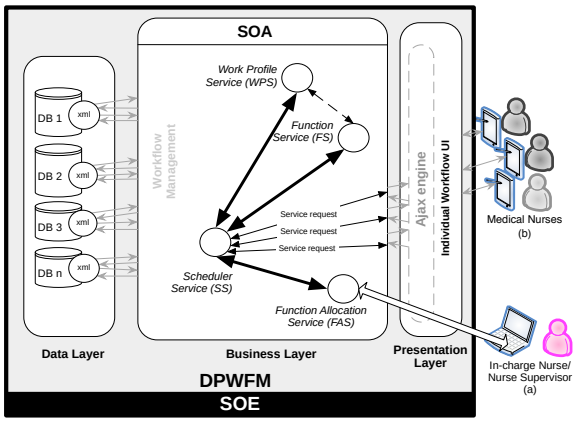


**Fig. 8. An interactive web applications environment for: (a) supervisor and (b) end-users**

The presentation layer is an interface layer that provides facilities to construct and customize user interface that is suitable for each level of users. The work schedule, which has been dynamically compiled into web application, will be presented with the appropriate widgets for users to interact with the application. In this layer, we are using Ajax as the user interface engine to provide dynamic web interface, users can observe changes to their web pages immediately, when their superiors assign or reassign jobs or projects to them.

As shown in Fig. 8, an in-charge nurse or a nurse supervisor (Fig. 8(a)) assigns the workflow requirements in FS based on their web services for their subordinates in FAS. The supervisors can access and modify the assignments at any time. Employees or end-users (for example, the medical nurses) can access the system with their own username and password (Fig. 8(b)). The complied web application provides the guiding principle to staff. That shows the assignments and the steps, which are the optimized schedules.

Fig. 9 shows the related function services for the supervisors. Once they have selected the needed FSs, the proper sequencing of WPS will be sequenced into individual worksheets, which will be presented as unique web pages for each individual nursing staff (see Fig. 10). A nurse has to complete the group of high-priority tasks (or pre-requisite tasks), and follows by the tasks that are of lower priorities until all tasks have been completed. The priorities are selected, computed and determined by using the business processing rules associated with the particular nurse's work practices and schedules. Sequences of FS will be set up and

linked to the WPS in the initial process. The optimal workflow will be calculated and complied into web application as the designed work schedule for the particular nurse. This will not only helps an individual nurse to complete their daily tasks, but also provides a simple workflow management in the hospital ward.

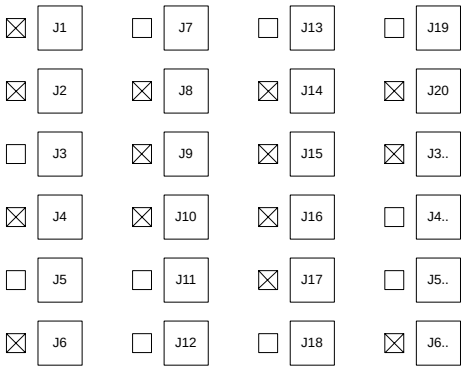


**Fig. 9. The alternatives Function Services (FS)**

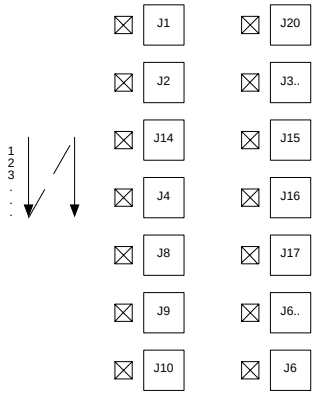


**Fig. 10. The Scheduled Services (SS) allocate a new set of Function Service (FS)**

## VI. Conclusions and Further Study

This research has proposed the DPWFM framework that allows web services related to work practices to be dynamically compiled into workflow web applications. These applications are then assigned to staff in an organization. DPWFM has integrated the decision making process of business process management with information technologies to provide facilities to each functional unit of an organization to tailor their workflow requirements. Staff in the organization is permitted to access, control, and customize their workflow requirements according to the organization rules and policies.

Our next immediate goal is to evaluate the effectiveness of DPWFM. DPWFM is currently being investigated in a pilot study to study the BPM requirement of a healthcare sector in Australia. Preliminary observations show that DPWFM is able to provide significantly improvement in workflow performance for healthcare providers.

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