Master of Software Engineering Project

for

Clinical Pathway Creator

Version 1.0

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MIn Zan	18/4/2016	Added the introduction section	0.1
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1 Introduction

Different from traditional domain, health care is a kind of intelligence intensive work. It has high requirements for relevant personnel and strict operation process. Doctors or nurses are required to make critical decisions to deal with patient's symptoms during a very short period of time, especially in the emergency department (ED) where is known to cause stress to be accumulated [1]. This is an extremely crucial and complicated process, which means health care providers must accord to professional knowledge, medical evidences and medical guides to ensure their diagnosis and treatment accurate and in time. For novices, sometimes, it is really of great difficulty to take steps to deal with such emergency due to lack of knowledge.

For doctors also need some facilities to assist them make decisions when in doubt. In this circumstance, medical guidelines would play an important role in assistance [2]. Junior clinicians may require the guidance more frequently and follow the guidance step by step, while experienced doctors tend to have a free hand and need guidance for checking uncertain. Hospitals also have recorded the best practice for treating medical conditions, which is an important complementary for academic guidelines. All of those performances could be abstracted as a medical model in the form of 'Clinical Pathways', which is just a tool designed to help general practices manage and refer patients to secondary and further community services.

1.1 Background

1.1.1 The Definition of Clinical Pathways

There are various definitions of clinical pathways from different point of view. Actually, there is no standard definition for clinical pathways [3]. It concluded that clinical pathways are tools that used to manage the patient care and standardize the care processes, based on documenting the hospital's best practices and evidence for each medical condition. It contains management tactics to provide action sequences to achieve decision making goals with optimal methodology. In this sense, it is a distinctive category of workflow with a number of merits [4].

To a certain extent, clinical pathways is a kinds of workflow, but clinical pathways have their own features. For example, in traditional Office Automation(OA) workflows, the processes and steps are tending to be fixed. It is clear what to do next, and the direction of workflows are basically single way. There are relatively fixed processes and steps, basically a linear process. While the workflows in clinical pathways are more dynamic and varied. The sequences among present to clinicians, examine, diagnose, treatment will be very disordered and are usually turned to be complicated iterations. Almost each step in four could lead to any other step. The decision factors will vary, under different context. Therefore, from the view of highest level, the clinical pathways is more likely to be an Incremental model rather than a flow model. It is very hard to be implemented by traditional computer language and data structure. It is more flexible and required to be descripted accurately. This is the core problem need to be solved in clinical pathways system. Through the analysis of different existing modeling languages, the PML language is chosen as the most suitable one. The obvious advantages of PML is that, apart from the flexible description of following actions, PML adds tight information

communication between relative actions. Thus, in addition to the restrictions on the actions, there are also strict restrictions on the resources needed for actions. With the resources information needed or produced by each action, it is much easier to create the sequences between each action. The action flows and step branches become more clear [5].

1.1.2 Why Clinical Pathways

A great amount of reports indicate that clinical pathways can play a very important role in health-care supporting process. It is a versioned document of medical guide, and offer users a process which is well structured, based on evidence and practice [6].

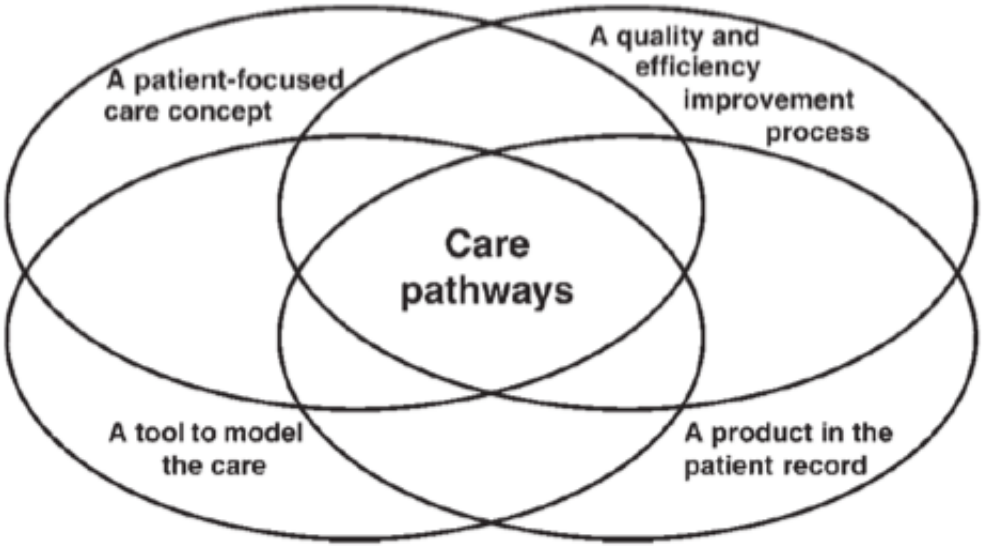

Figure 1: clinical pathways as a concept, model, process and product

- Clinical pathways could decrease the duration of the production process [6] which reduces waiting time significantly. Especially in Emergency Department, the faster the diagnosis is established, the quicker treatment can be implemented.
- Clinical pathways could increase interactions between different departments that are involved in the production [6]. At the same time, evidence-based interaction between patients and doctors could provides a better overview of illness.
- Clinical pathways could also reduce the risk of errors [6]. Every step of Clinical Pathways follows medical guidelines or practical experiences, which provides accurate instructions to both novice and experienced doctors.
- Clinical pathways could reduce the cost of the production process [6]. Standardized actions and optimized process ensure maximum usage of equipment and other resources which leads to effective reducing of costs.

- Clinical pathways increases the job satisfaction of employees [6]. Automatic frameworks cut down more inefficient work behaviors which turn down the labor strength of staff.

Indicators	Before (178 cases)	After (68 cases)	*P* value
Rate of diagnostic agreement between emergency room and general medicine unit	NA	77.78%	NC
Average length of stay (days)	10.89	7.96	<0.01
Rate of completion of clinical records in emergency room	21.71%	26.29%	NS
Rate of completion of clinical records in general medicine unit	26.29%	62.86%	<0.01
Proportion of patients with left ventricular function assessment	44.94%	100.00%	<0.01
Proportion of smoker patients with advice/counselling for smoking cessation	NA	100.00%	NC
Proportion of patients with written discharge instructions (activity, diet, etc.)	0.00%	100.00%	<0.01
Proportion of patients with ACE inhibitor at discharge	12.36%	20.59%	NS
Rate of unscheduled readmissions within 31 days	6.74%	2.94%	NS
Total in-patient mortality	17.42%	4.41%	<0.01

Figure 2: The result of implementing Clinical Pathways for heart failure

The figure above, according to a research in 2003 [7], shows that the heart failure decreased after following the clinical pathways. It is clear that the rate of diagnostic agreement between emergency room and general medicine unit is extremly changed by using clinical pathways. Other data also change after implementing clinical pathwyas during the patient care. Clinical pathways was definitely helpful for clinical risk management and cost saving.

1.2 The problem of Clinical Pathways

1.2.1 Accessibility

Although searching clinical pathways is already available from the internet, it often returns a large list of results, many of them may not clinical pathways. It is difficult for hospital staff to find what they need. Also, most of the current clinical pathways is stored in the form PDF or document files with no interactivity. A more interactive way is need to help hospital staff making decisions.

1.2.2 Reflection

To keep updating the latest clinical pathways is difficult. Medical evidence changes often [8]. 90% of medical guidelines are valid only for 3.6 years and 50% of medical guidelines valid for 5.8 years. At the same time, hospitals could not make changes for their clinical pathways in accordance with their own medical evidences, which means that clinical pathways face a lot of edit, modify, and update problems.

1.3 Project Goal

The goal of this project is to create a pathway editor which provides the link between current clinical pathways and hospital staff as well as transfer the PDF or document files into electronic clinical pathways which can guide hospital staff in a more interactive way, help hospital staff to make accurate decisions and improve their working efficiency. The system should be user friendly image, simple, easy to understand and follow as the main user of the system will be old people with no or less computer experiences. Additionally, clinical pathways created by the system should can be used in different size and in different devices, such as laptop and mobile phone.

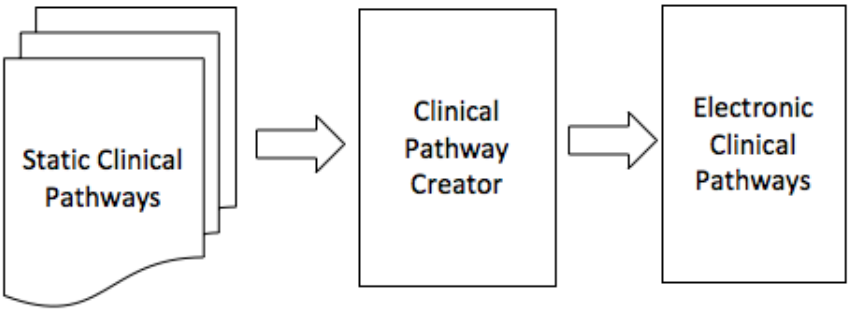

Figure 3: The goal of Clinical Pathways

2 Literature Review

2.1 Clinical Pathway Editor

2.1.1 User Interface

The importance and difficulties of electronic clinical pathways editor has been addressed in many researches and reports [9]. Figure 4 shows that twenty-six studies considered the problem of how to integrate a clinical process User Interface model which presents the most studies in the cluster. While in figure 5 each cluster is shown as a circle, the number in the circle means the number of papers in the cluster. It is shown that the User Interface plays an important roll in Clinical Pathway Editor.

ID	Studies in the cluster	Cluster description
10	24 Studies[8 14 46 61 67 68 71 73 78 83 85 90 91 96 108 111 112 116 118 121 126 129 134]	Creating a procedural, clinical process model aided by knowledge acquisition tools and supported by the system architecture; mapping declarative concepts between a local electronic health record (EHR) or 'virtual medical record' model and the process model; user interface (UI) and usability design congruent with the model; separation of organizational, medical, and UI models
3	23 Studies[34–36 42 43 45 51 52 59 81 84 87 97 100 105–107 110 113 123 124 133]	Collaborative process between informaticians and domain experts of translating implicit, procedural knowledge into computable rules; extracting declarative and procedural knowledge into a process model; localization of the guideline/pathway for a specific institution and mapping to the local EHR
1	15 Studies[3 4 39 41 60 74 86 92–94 103 104 115 125 128]	Integration of clinical and organizational processes with regard to institution-specific clinical workflow and preferences; handling workflow exceptions (adaptive organizational workflow); bindings/congruence of enacted workflow with documented clinical processes
9	12 Studies[49 62 65 66 72 76 88 98 99 101 102 122]	Verification and validity of the clinical process model; formal proofs; model-driven update and maintenance of the knowledge base
7	8 Studies[35 44 47 48 57 58 70 79]	Clinical validity of EHR—guideline concept mappings; verification of rule-set completeness and consistency; verification and validation of temporal constraints and run-time execution
2	8 Studies[50 54 75 89 95 114 119 135]	Enactment of the model within local EHR/health information systems (HIS); handling clinician judgment, task sequencing, and temporal constraints, exceptions, variance (adaptive clinical workflow)
5	7 Studies[17 36 40 53 55 56 109]	Addressing usability barriers to implementation of a computerized guideline or pathway; integration with clinical and organizational workflow; development of new tools to support clinical workflow; modification of existing workflow to fit computerized workflow; reporting workflow/pathway statistics, and exceptions
6	4 Studies[12 77 82 132]	Formal modeling of clinical goals and their temporal constraints; separation of clinical and organizational knowledge; allowance for unplanned run-time deviations in the model
4	4 Studies[63 69 130 131]	Handling of complex temporal expressions within the pathway that provides adequate abstraction while remaining computable (trade-off between expressivity and complexity)
8	3 Studies[38 80 117]	Overcoming the organizational and individual barriers to implementation of a computerized workflow, guideline, or pathway; need for both computerized and real workflow to adapt to each other

Figure 4: The frequency of user interface mentioned in Clinical Pathways

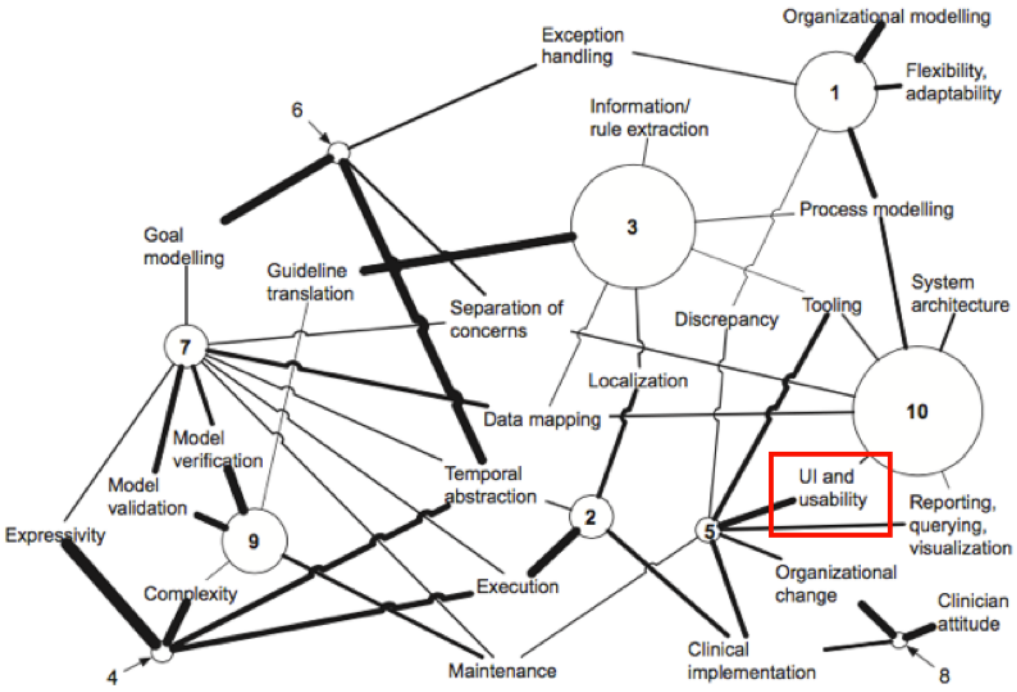

Figure 5: The importance of user interface in Clinical Pathways

2.1.2 Problems

To establish a practical and efficient clinical pathways system is of great difficulties and challenges. Currently, according to the latest research and analysis of ATSC in Royal Hospital Adelaide, clinical pathways system is encountered a lot of problems [10]:

- Most of the Pathway is stored as PDF documents. Medical staff can not very easily to find an accurate pathway to comply with.
- The current system does not provide efficient clinical pathways search and interactive solutions, so in an emergency, the existing clinical pathways system lacks sufficient usage and adherence.
- The existing establish clinical pathways is not suitable for elder doctors and professors to used. The major user of clinical pathways editor is senior exports. However, these doctors, professors are tended to be unfamiliar to operate computer. The current system is not user-friendly to elder users.

According to the analysis above, the most important problem of current system is lack of accessibility and adherence. To upgrade clinical pathways editor is one of the most significant aim of our work. Our project will be mainly completed the following goals:

- To update the frameworks of current clinical pathways editor, implementing the latest SPA technology. Rewritten clinical pathways editor.
- Greatly enhance the interaction and user experience of clinical pathways editor so that users, especially the elder users, could use it effectively and efficiently.
- The clinical pathways editor will also integrate with intelligent search, input assistant and other functions to enhance the clinical pathways edit.
- The new clinical pathways editor will also can be deployed on PC, Pad, and other mobile devices.

2.2 Existing Clinical Pathways

2.2.1 NICE Pathways

The National Institute for Health and Care Excellence (NICE) used in hospitals throughout the United Kingdom that provides advice and guidance, developing quality and performance standards for public health and social care practitioners to improve national health care. An online tool provides quick and easy access guidance from NICE to help patients and health care staff.

The NICE pathways only provide guidance and advice written as text to doctors. It cannot help the health care staff to make ultimately decision. As illustrated in the figure below, making evidence based medical guidelines has already accessible. Clinical pathways that the accessible required is a system that existing document pathways can be added and updated as well as reflected on the latest

information. In addition, the pathways must be accessible in the emergency department and followed with interactive software.

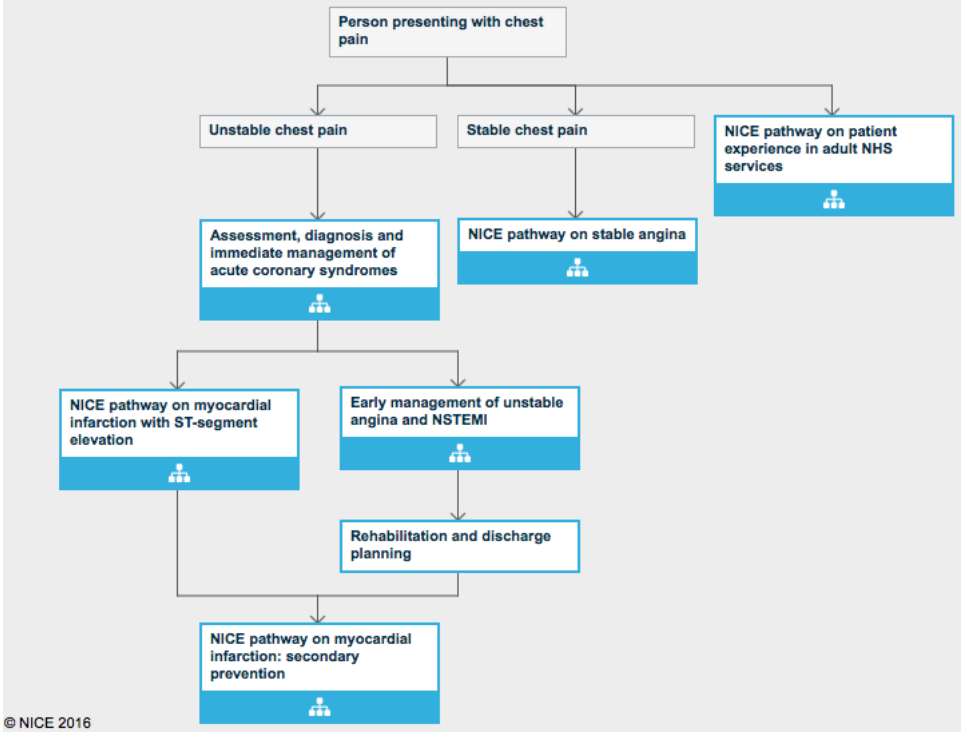

Figure 6: NICE Pathways

3 Solution

3.1 Nature Language Processing input assistance

This project will apply Nature Language Processing (NLP) function to increase information input speed and enhance input accuracy. This is very important for elder users. Clinical Pathway project and NLP project communicate with each other by agreed API. The integration of two projects enhance the efficiency of clinical pathway creation.

3.2 The interface of clinical pathway creator

The main interface can be divided into two part: the form logic and the right part.

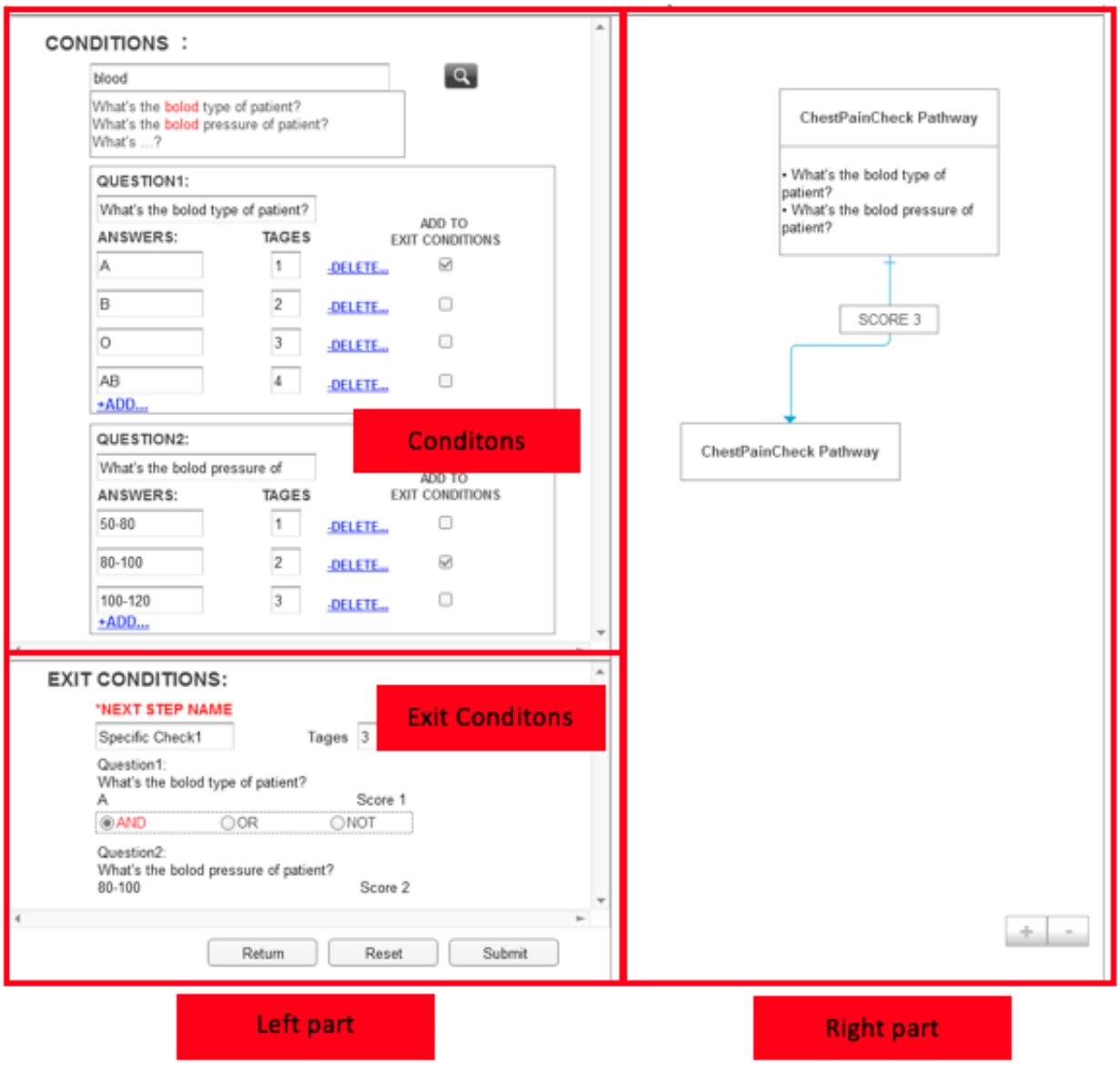

Figure 7: Two parts of interface

3.2.1 The left part (Form logic part)

The function of left part is focused on pathway information input. The pathway information could be classified into two categories. One is called Conditions. This information is mainly about medical guidelines, with more nature style like questions and answers. Another one is Exit Conditions, which are a combination of conditions picked up from original conditions. It means under these condition, a specific action would be taken in next step. Different exit conditions lead to different action. The group of conditions involves complicated logic. Using a proper interface to achieve high productivity of exit conditions generation is names as Form Logic in this paper. It is a major problem that should

be addressed in this project.

3.2.2 The right part (Graph logic part)

The right part is used to visualize pathway information. The pathway data is very different form Object-orientated data. The feature of it is to describe the relationship between information and process or the relationship between process and process. Hence it could be recognized as a Process Modelling Language (PML)-like data. Using a suitable visualization methodology to illustrate all these relationships more legibly is named as graph logic is this paper. It is another crucial problem that should be addressed in this project.

3.3 Form logic implement

We have already examined many existing solutions about clinical pathway logic. One of them is based on Risk Management Process (RMP). The core technique of this approach is to grant each condition a score. The exit criteria are according to the range of the sum of exit conditions scores. It is very effective for risk evaluation, but not feasible for build a clear logic between each steps. The optimized interface design has already been proposed in the initial stage of project design, due to the significant drawbacks of RMP, that version have not be adopted. The new solutions are based on the analysis of form logic. There are 2 plans to actualize it.

3.3.1 Conditions-first approach

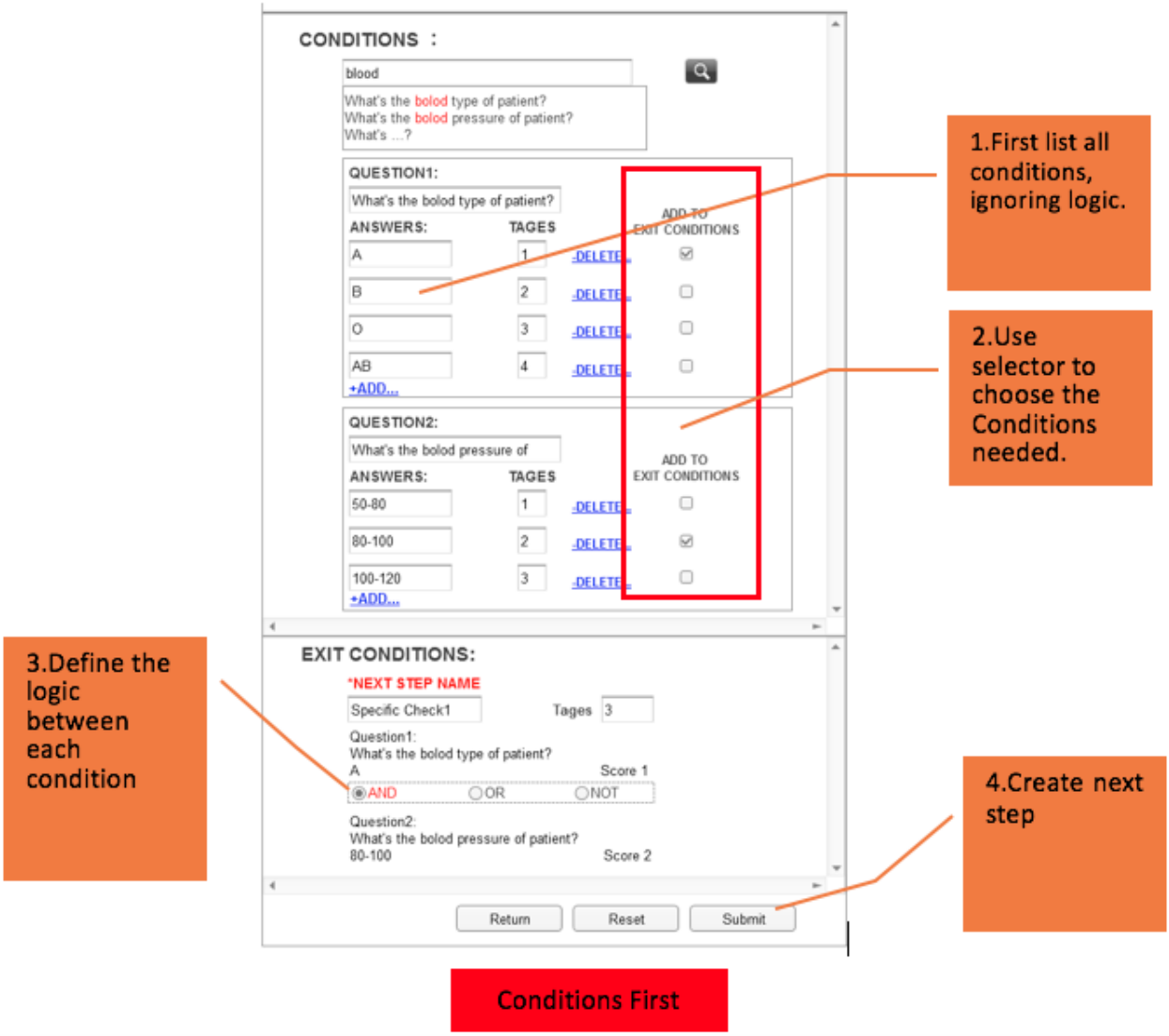

Figure 8: Conditions First

Firstly, user needs to illustrate all conditions. In this stage, the is no specific relationships between each answers or questions. By using selector, such as check box, user could select the questions and answers needed. At the same time, system would automatically add these conditions into to exit conditions. The relations between those conditions are linked by logic operators, such as and, or and not. Finally, user could create next action by combined exit conditions.

Advantages:

- Quick for user to illustrate all conditions.

- Quick for user to select conditions.
- Quick for user to build exit conditions.
- Conditions could be reused any times.

Disadvantages:

As the logic operators are powerful, if they are not used appropriately, the logic could become chaos.

3.3.2 Logic-first approach

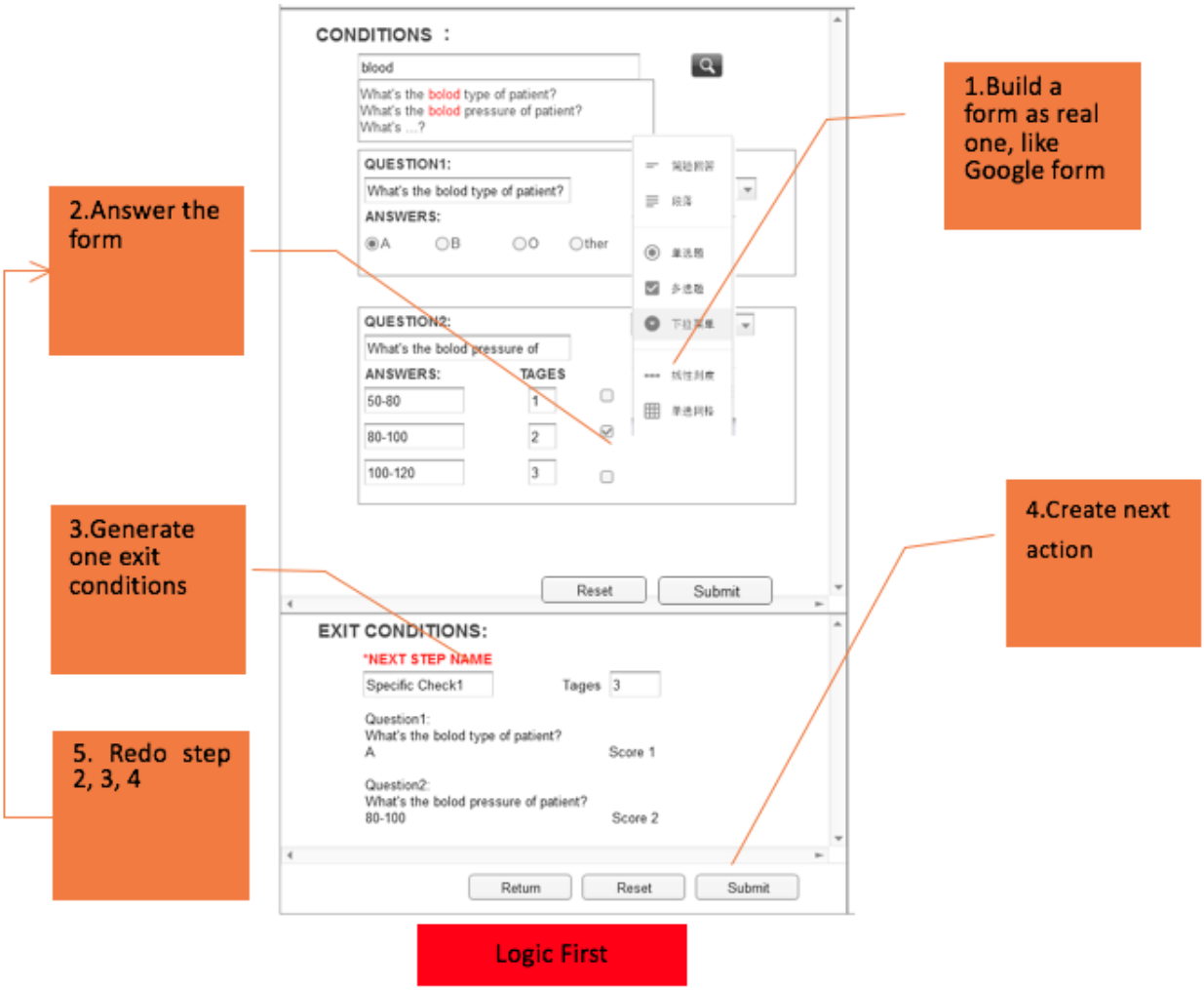

Figure 9: Logic First

First step, user needs to build the form. This form is almost the same as a real survey. So the logic between each conditions are established at this time. After the form is finished, user need to fulfil it

to generate one exit conditions. The last step is to crate next action.

Advantages:

- The form created is very formal.
- The whole process is very standardized and formative.
- The form can be saved as a record.
- The process is very easy to understand.
- The logic between each condition is very clear.

Disadvantages:

User fulfil form once, could only generate one exit conditions. So the productivity of these approach is not high.

3.4 Graph logic implement

The pathway is a complicated structure of work-flow graph rather than an traditional chart. To display it more logically, the best approach is to redevelop existing work-flow JS libraries. There are some candidates:

- GoJS: (The best one)It is a feature-rich JavaScript library for implementing custom interactive diagrams and complex visualizations across modern web browsers and platforms.
- JSPlumb: (good at drawing we only need displaying) jsPlumb provides a means for a developer to visually connect elements on their web pages.
- D3JS: (highest rating but suitable for char not work-flow) It is a JavaScript library for manipulating documents based on data.

By carefully evaluating 3 main diagram JS libraries, GoJS is the preferable one to be adopted. It is specialized in work-flow chat illustrating. The design of graphic clinical pathway plain is shown bellow:

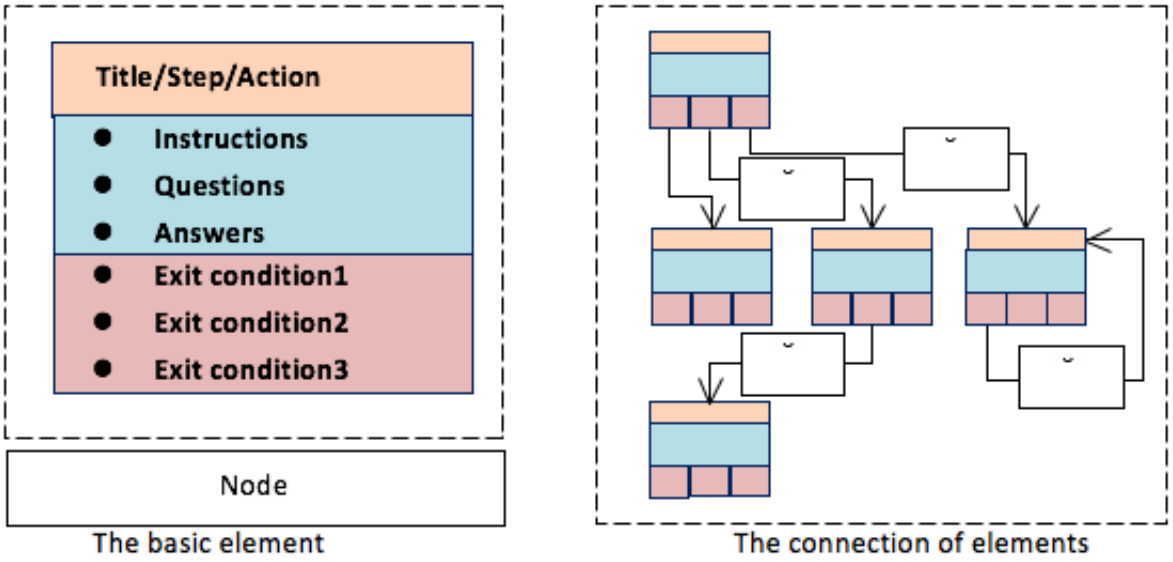

Figure 10: Node and connections

Particularly, in order to show information of each element more clearly. We chose accordion design of each part of node. The layout of whole clinical pathway could be Horizontal.

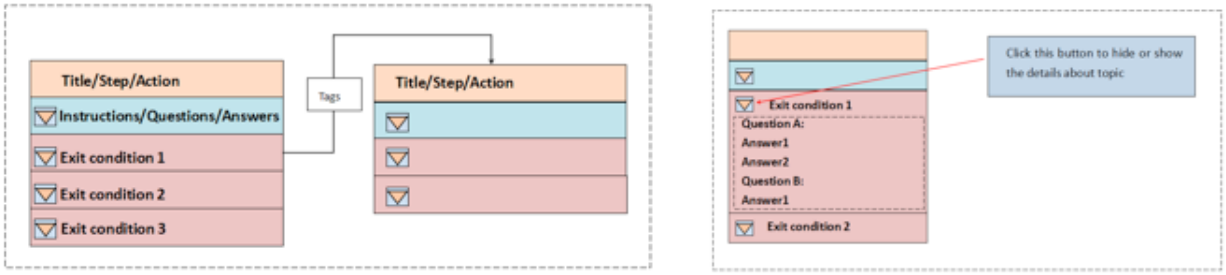

Figure 11: Horizontal connect and accordion

3.5 Architecture technology

Because many function of this project could be completed in one page. So we adopt SPA Framework and technology for this project. Attemptting (1) Ruby on Rials: It is a full stack, Web application framework optimized for sustainable programming productivity, allows writing sound code by favouring convention over configuration. (2) AngularJS: It is an ideal front-end framework for an application built on top of a RESTful API. Using two way bounding and templates, AngularJS is very suitable for form based applications. The form logic part of this project would be benefit a lot form this. (3) GoJS: It is very good at implementing graph logic part of this project. (4) Json: It is widely used for JavaScript data transformation. (5) RequireJS: it is used for components loading management (6) NodJS: it is a JavaScript runtime built on Chrome engine. It uses an event-driven, non-blocking I/O model that makes it lightweight and efficient

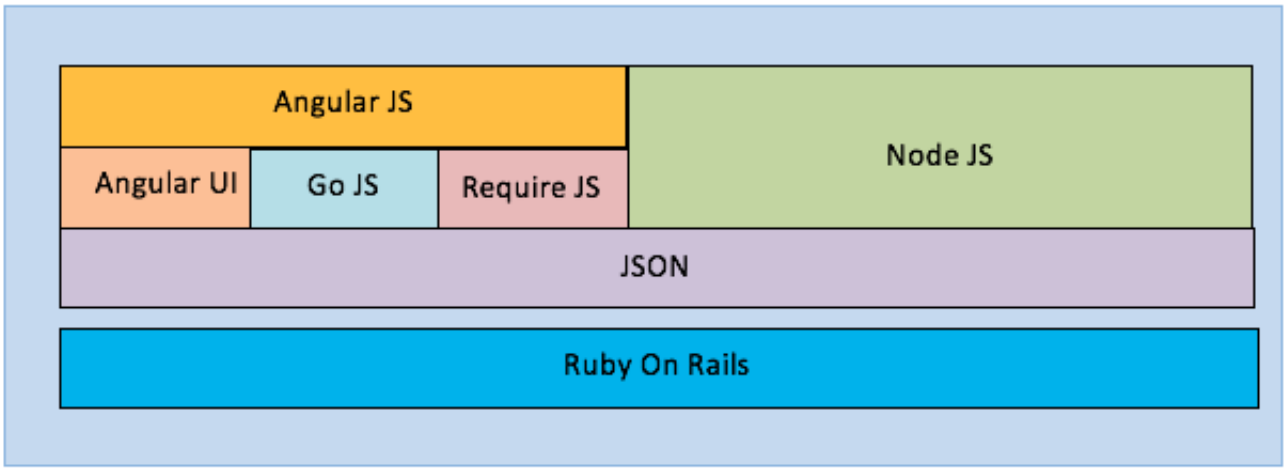

Figure 12: The technology structure

4 Project Plan

	Min Zan Graphic Logic	Yuzhu Wang Form Logic
Week 7	Interface & User requirement freeze. Finish graphic logic part requirements specification.	Interface & User requirement freeze Finish form logic part requirements specification.
Week 8	Finish software design of graphic logic, including architecture design, components design and class design.	Finish software design of form logic part, including architecture design, components design and class design.
Week 9	Start with "basic" map structure, try to implement "nice" map structure.	Start with "basic" appearance, try to implement "nice" appearance.
Week 10	Complete proposal Implementing.	Complete proposal implementing.
Week 11	Combine the proposal with form logic part.	Combine the proposal with graphic logic part.
Week 12	Demonstrate pathway editor proposal.	Demonstrate pathway editor proposal.

Figure 13: Project Plan

5 Conclusion

We have had a basic understand about the clinical pathway creator system. The system will be mainly used by medical experts to create new clinical pathway or reflect the existing clinical pathways which are in the form of PDF or document files into the clinical pathways system. The system can support clinicians interacting with every stage of the clinical process. The system can also provide digital clinical pathways which the doctor can access to, by using mobile phone and other mobile devices instead of holding a lot of complex document files at the care point when a patient is being treated.

We believe that this approach will be well suited for supporting staff in hospital, especially novices who may need advice and guidance at every stage of process execution. Our initial design of the system has been positive, since our aim is to create a clinical pathway creator which is easy to understand and use. We believe that our approach has potential and plan to do more research to find a better solution and create a prototype system during this semester.

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