Story Decorated Learning Activity Generation in a Context-Aware Mobile Role Playing Game

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Abstract: Game-based learning is a popular method and has implemented on mobile platforms to make ubiquitous learning more efficiently. However, most of mobile educational game researches focus on specific topic/discipline/curriculum with small applications and few researches consider attracting users playing the educational game continuously. In this research, we design a Context-Aware Mobile Role Playing Game (CAM-RPG for short) that can generate a series of story-based quests (i.e., a quest chain) automatically for users and make the users interact with specific real (e.g., projector, rest room, pine tree, etc.) and virtual (payroll system, business policy, E-Commerce course, etc.) objects in the real world. The useful contexts are filtered out by using information theory and rough set and then are re-organized into a series of learning activities (i.e., a learning activity chain). To make the learning activities attractive to the users and make the mobile game become an immersive learning environment for the users, we analyze and apply narrative elements into the learning activity generation process and transform the learning activity chain into a quest chain in the game.

Keywords: narrative, educational game, game-based learning, context-aware, situated learning, mobile learning, automatic generation

1. Introduction

According to the statistics in 2010, vendors and manufacturers can produce and sell more than three hundred millions smartphones and have 72 percent increasing from 2009 to 2010, moreover, smartphones occupied 19 percents of mobile communication device sales in 2010 (Pettey & Goasduff, 2011). These statistics data shows the rapidly growing of smartphone market and indicates the changes of using mobile phones. With the mobile platform features such as portability, multi-media capacity, wireless Internet access, and location-aware potential (Kim & Schliesser, 2007), mobile applications are widely used and bring the opportunities to various domains including education, transportation, healthcare, tourism, and training.

With the emerging trend of mobile application development, many researchers use mobile devices to make learners have feelings that they are living in the era or the place which they can obtain the knowledge, e.g. the users can learn rainforest plants and ecology in the Amazon River zone of a botanic garden, that is so-called mobile/ubiquitous learning (Chang & Chang, 2006; Chen, Kao, Yu, & Sheu, 2004; Kurti, Milrad, & Spikol, 2007; Wu, Yang, Hwang, & Chu, 2008). Some other researchers develop mobile games for educational purpose; these games not only make learners doing learning activities in authentic environment such as museums and historical sites, but also make them get motivated if compared with the abovementioned mobile learning systems (Chang, Wu, Chang, & Heh, 2008; Wu, Chang, Chang, Yen, & Heh, 2010)

However, most of the existing research on mobile learning and game-based learning focus on specific discipline or curriculum in educational settings (i.e. school campus, museum and historical site) only. The games will be boring if it just asks users to do the activities one-by-one. Few research talks about how to design the contents of mobile educational games and make users feel interesting and want to play the game continuously. This research is to apply the narrative theory to design an educational role playing game in order to make users feel that they are living in the game world and role play an actor, explore the game world, complete the quests, and learn something.

The rest of this paper is organized as follows. Section 2 first talks some definitions and previous relevant research works that this research uses in designing the game and the narrative structure. Section 3 introduces the learning activity generation process we have designed. Section 4 describes the design of narrative elements and narrative knowledge structure which can be used to generate storylines and to

package the learning activities. Section 5 presents the storyline generation process as well as generates the learning activity chain automatically. Section 6 presents the system prototype and the game-play situation. At the end, Section 7 makes conclusions and talks about the possible future works.

2. Narrative and storytelling in games

There are many different game genres (ACMI, 2011), and two of them are rather suitable and are considered frequently for educational purposes: adventure game and role-playing game (Cacallari, Hedberg, & Harper, 1992; Frazer, Argles, & Wills, 2008). During the adventure journey of the game-play in these games, players may encounter missions, tasks, and questions. The implicit knowledge or solutions for these quests need players' judgments and reactions. The challenges that a game gives to the players and the pleasure experiences that players gain from the achievements in the game also motivate them playing the game continuously and foster them understanding domain knowledge comprehensively (Garris, Ahlers, & Driskell, 2002).

To create a joyful game and game-play experiences, it is important to think of using drama, storylines, humor and characters. Dickey (2006) presents an overview of game genres and analyzes how important that narrative plays in the educational game design. Some researchers also propose that the use of narrative in the game design makes players have empathy toward the characters (i.e. have pity toward the victim character or feel responsibilities like a hero). The generated fun and empathy of a game attract players to involve constantly (Aylett et al., 2006).

Storytelling is a critical part in designing an interesting and engaging game. Most of popular games have its background story no matter the story is a simple linear story (i.e., saving the princess) or a complex drama (i.e., the war between Alliance and Horde). Good storytelling in the game design makes the game realistic and immersive as well as users involve constantly. Therefore, it is important for designers to understand classic story structure. Generally, a story usually begins with a basic concept or an idea. The basic idea is to place some characters, in some situations, in some settings in the game. (Rabin, 2010)

In order to make the context-aware mobile role-playing game interesting and engaging to uses, we take narrative elements into considerations. The narrative elements such as storyline, character, and interaction have been analyzed and used in the game-based learning system design (Ying, Wu, Chang, & Heh, 2009). Conle (2003) summarizes that narrative involves temporal sequences, plots, characters, context, and the sense of an ending. Some researchers have done the research of finding the relationships between narrative elements and game (Mallon & Webb, 2005). They argued some narrative features such as causality, temporality, and linearity, should be considered to make an interactive and engaging game.

Knowledge structure can be traced back to the memory model proposed by Quillian in 1967. After that, several knowledge structures are proposed to visualize concepts via graphs. Novak and Gowin (1984) have proposed a structure called concept map, they use graph to organize and represent knowledge. The concept map uses circles or boxes to represent concepts, and connects two concepts with undirected line to represent the concept relations. Another well-known theoretical structure called Semantic Network which is proposed by Sowa in 1983. Semantic network is a systematic means for researchers to model an individual's mental schema of declarative knowledge (Fisher & Hoffman, 2002).

Wu and colleagues (2008) propose the ubiquitous knowledge structure for museum learning and elementary school level botanic learning (Wu, Chang, Chang, Liu, & Heh, 2008). It has been proved as a good way to store the knowledge that learning objects (in the real world) and materials (in the textbook) may have. Its hierarchical structure is easy to understand and to manage for everyone (i.e. school teacher and system manager) and there is no specific rule of building a knowledge structure. In addition, it can be applied to various domains/disciplines.

In this research, we define several narrative elements including "plot", "time", "place", "character", and "character's context" (i.e., character’s items, actions, and emotions). Furthermore, we combine these narrative elements and the idea of ubiquitous knowledge structure to create a narrative knowledge structure in order to generate stories for learning activity chain decoration. The story generation will be described in Section 4.

3. Learning activity generation

Learning activity generation is the fundamental of the proposed game. The game uses context-awareness knowledge structure to store the environment information and its learning objects, furthermore, uses the activity generation engine to generate a series of learning activities. Figure 1 shows the learning activity generation flow. This flow has six steps:

- Analysis: All the learning domains and corresponding objects which users can learn in the authentic environment are listed and then all characteristics of the associated learning objects are identified and figured out. This analysis result is stored into the context-awareness knowledge structure.
- Role & theme: At this step, users can choose preferred role as well as the theme they want to play.
- Activity generation: The game feeds the chosen role and theme into the activity generation engine to generate learning activities.
- Learning activity chain: The activity generation engine compares the information values that learning activities have and sorts it into a chain.
- Learn by playing: Users follow the instructions and look for the designated learning objects to do the learning activities one by one.
- Personal experience update: the learning objects and related knowledge users have learnt will be stored in database to record their learning status (e.g. what learning activities they have done so far and what learning objects they have learnt) and performance (e.g. how well they did in doing the learning activities and how many learning activities they have done).

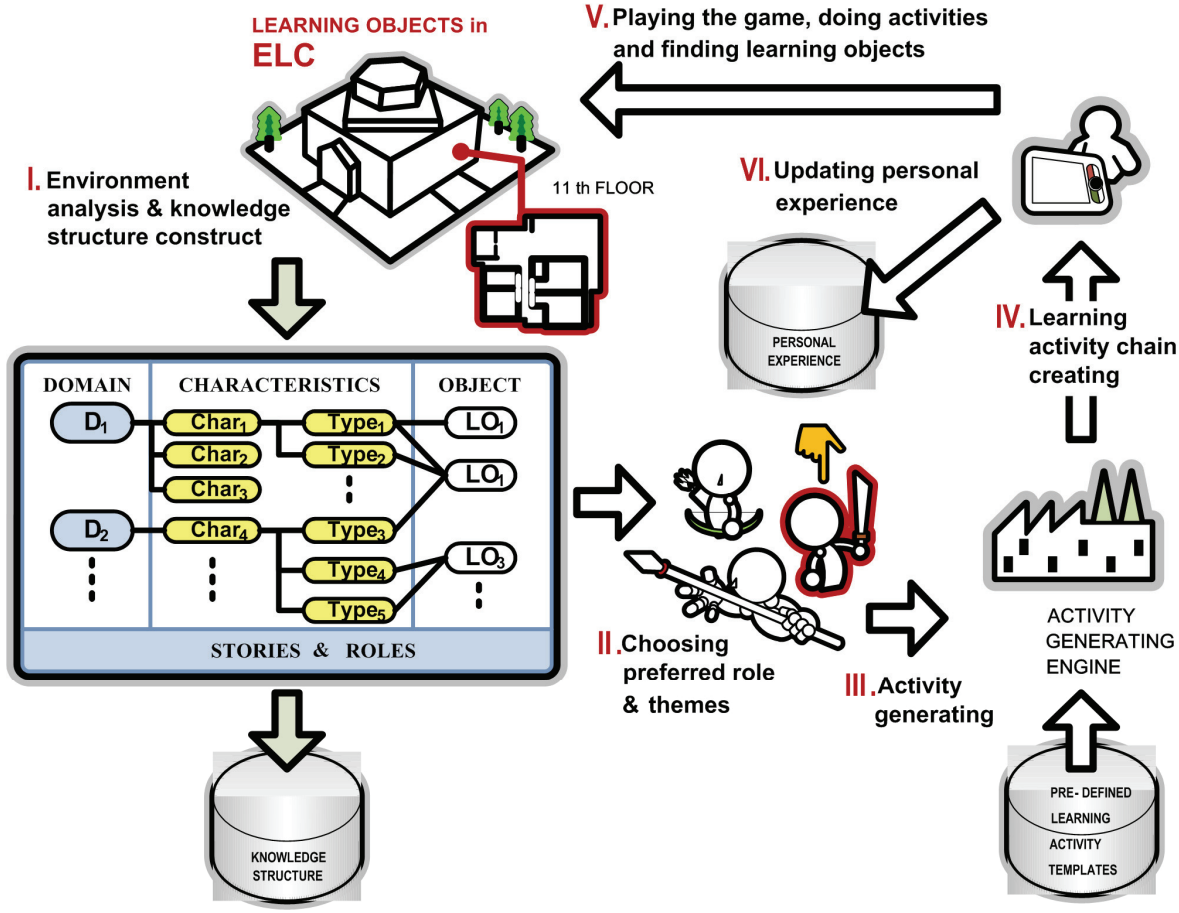


Figure 1: Learning activity generation flow

For generating learning activities, we adapt the three layers of the ubiquitous knowledge structure which proposed by Wu and colleagues (2008) to build the context-awareness knowledge structure according to the authentic learning environment that the mobile game takes place. Figure 2 shows the altered context-awareness knowledge structure in a learning environment of people's daily workplace: Domain layer defines Subjects and Topics as well as learning themes. In addition, different domains may cover same objects and characteristics. Characteristic layer is a hierarchical structure and may be associated

with many domains, has root characteristics and child characteristics. Object layer stores all learning objects in the real world, e.g. workplaces, equipments, devices, forms, flyers, etc.

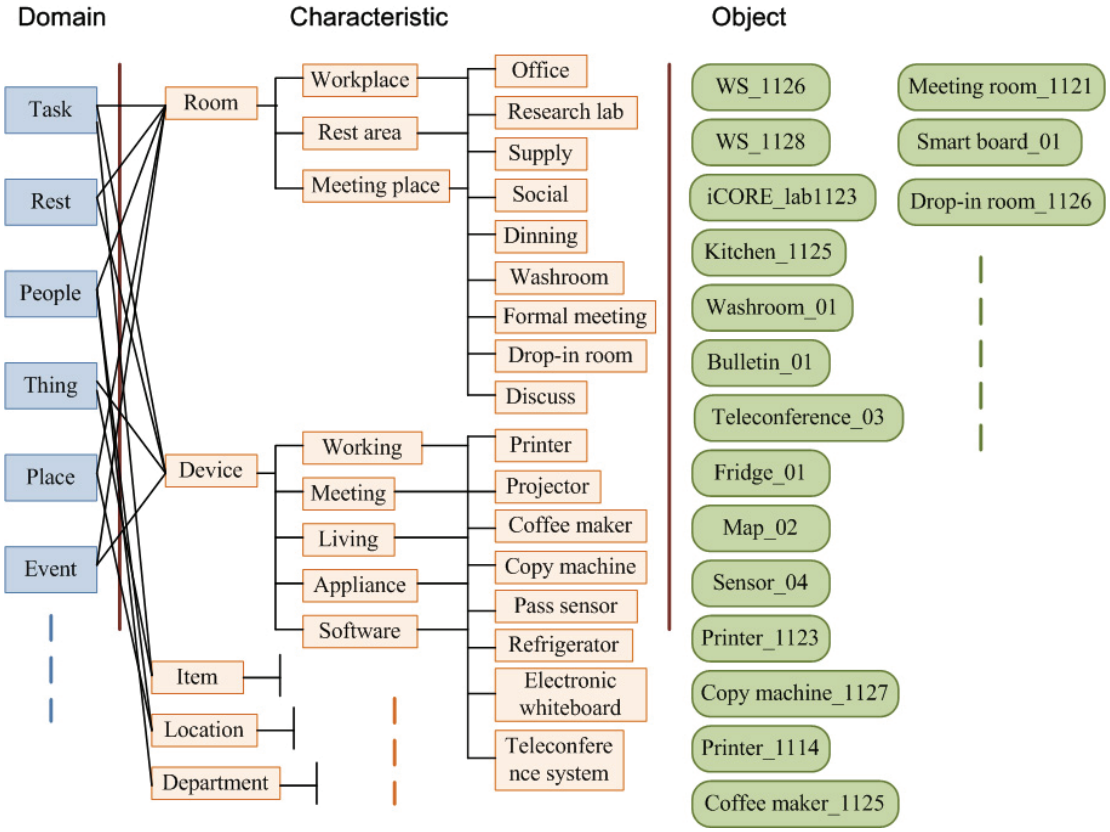


Figure 2: Partial ubiquitous knowledge structure for the 11th floor of Edmonton Learning Centre (ELC)

In the ubiquitous knowledge structure, each theme is associated with a domain and multiple themes can have relations with the same domain. For example, a theme - "Life style in the learning centre" actually associates with the domain - "Event", which covers the events happened in daily works. The engine retrieves all domain relevant learning objects and corresponding characteristics from the context-awareness knowledge structure.

After the learning activity generation engine has the relevant learning objects in the environment, the engine applies rough set and information theory to filter irrelevant learning objects and to weight the rest learning objects which match the chosen theme. The details of calculation can be found in our previous research (Lu, Chang, Kinshuk, Huang, and Chen, 2010).

After the engine weights all learning objects filtered and retrieved from the context-awareness knowledge structure, the game starts to generate theme relevant learning activities and puts learning objects into the activity templates. The templates can be filled up by one or more learning objects and characteristics, for examples, "looking for a [printer]" template may associate with "Characteristic - Printer" and "having [a cup of coffee] in the [kitchen]" template may associate with "Object - Coffee Maker 1125" and "Object - Kitchen 1125".

The engine uses the characteristics and objects retrieved earlier to decide whether a template could be used or not. If a template requires specific characteristic(s), the engine will generate learning activities by picking up suitable learning objects which have the required characteristics. Otherwise, the engine simply generates the activity instance(s) by filling the template up with the specific learning object(s) directly. The engine sums up the information values of the learning objects associated with the learning activity instances, which means, each learning activity instance has its own information value and the engine chooses one instance to represent the template. At the end, the chosen learning activities are put into a chain by sorting its learning object amounts and activity information values.

Figure 3 presents a generated learning activity chain for the role of visit scholar and theme of life style in the learning centre. The engine generates sequential activity chain based on two rules, (1) the activity

involves less learning object(s) has higher priority, (2) if activities involve same amount of learning objects, the activity with lower information value has higher priority.

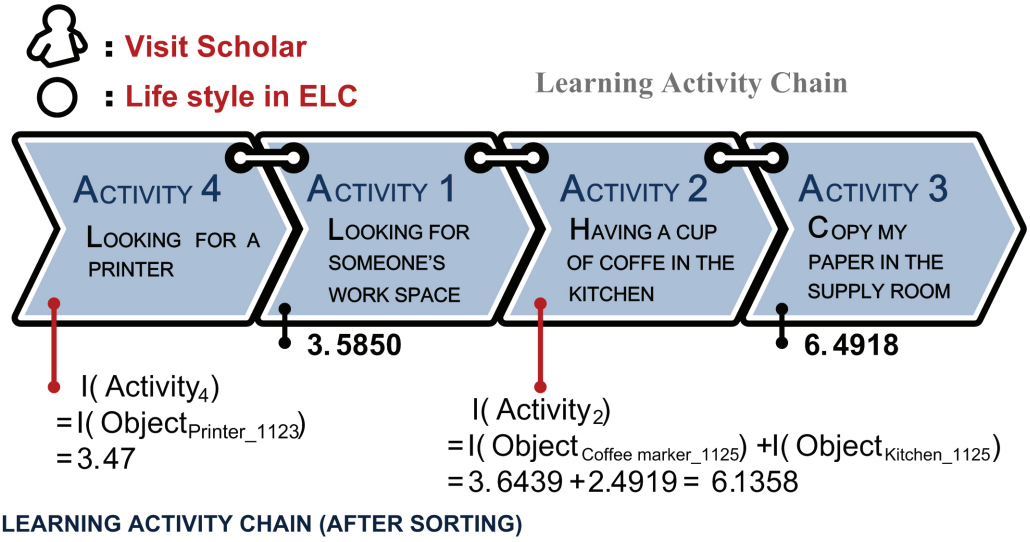


Figure 3: A learning activity chain example

4. Narrative knowledge structure

By combining the idea of ubiquitous knowledge structure and the four defined narrative elements, a four-layer narrative knowledge structure is designed to help the game generate stories for different chosen theme and learning activity chain's length. Time layer stores all time relevant elements that can be applied to the story. The elements in Time layer can have two kinds of relations including hierarchical and sequential relation. Place layer stores the place relevant elements to present virtual space, spots, and the relations between each others in the story. Character layer stores non-player controlled characters (NPCs) that can be used to deliver the story as well as interact with the users. Characters have optional properties such as its actions and emotions. These properties are stored as its schema to make the story generation engine vividness. At last, Item layer store all virtual items which may be used by NPCs and/or put at specific places in virtual space/spots.

By expanding the narrative knowledge structure, the composition of the narrative elements will be more diverse and richness. In addition, both context-awareness knowledge structure and narrative knowledge structure are easy to understand for general public (e.g., teachers and staffs in historical and cultural sites) and easy to build for different discipline. Figure 4 shows the narrative knowledge structure for storing narrative elements which can be used in the story generation process later.

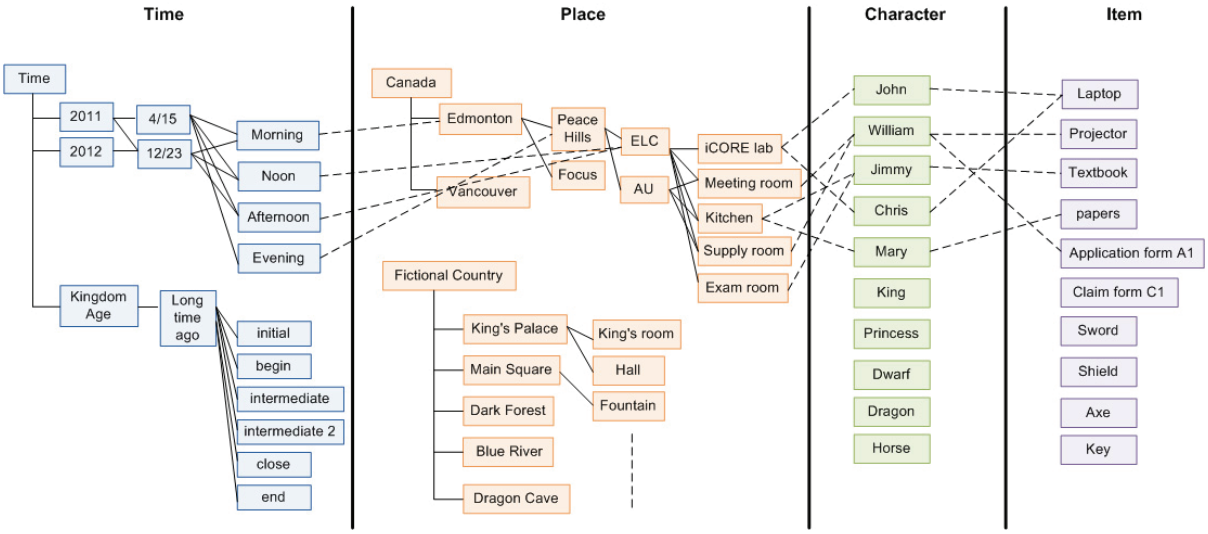


Figure 4: Narrative knowledge structure

In the narrative knowledge structure, each layer can have more than one level. The relation between elements is created optionally. The elements built in the narrative knowledge structure can be mixed of truth and fiction as Figure 4 shows. Different schema is designed to store the properties of narrative elements in each layer. The schema of narrative elements can be seen as the settings of the storyline and used in generating story. Figure 5 presents the schema of Noon element in time layer and William element in character layer.

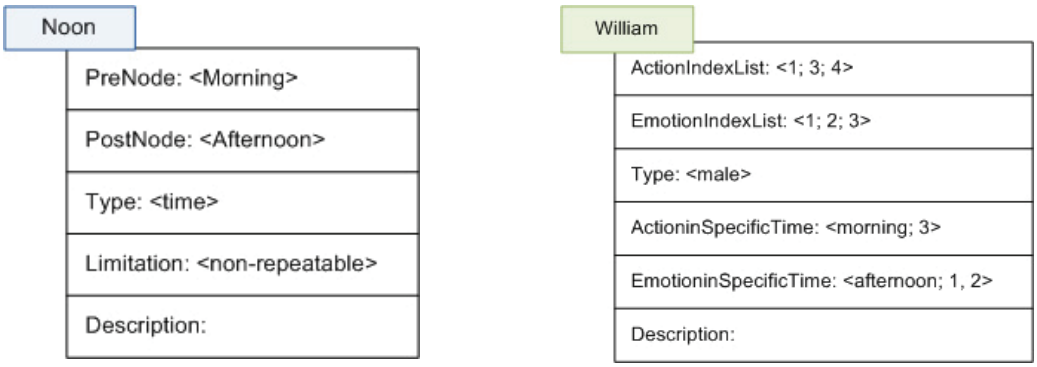


Figure 5: Narrative element schema examples

The abovementioned narrative knowledge structure and narrative element schema present a clear concept for the game's administrator (e.g., teachers) to build. The story generation engine then can generate a series of stories (i.e., a storyline) with the narrative structure according to the chosen theme and amount of learning activities.

5. Transforming learning activity chains into storylines

In this section, the story generation process and the learning activity chain decoration with the generated stories are talked. Unlike the learning activity generation engine which uses rough set and information theory to filter irrelevant learning objects and weight the information values, the story generation engine has four filters which are associated to the four layers of the narrative knowledge structure. In addition, a set of story template also pre-defined in the database. Story templates represent the concept of "plot" and the story generation engine can pick-up one or more templates to form a plot and connects several plots to form a storyline. The rest of this section takes the generated learning activity chain as Figure 3 shows as the running example to describe the storyline generation process.

The first step of the generation process is to retrieve a set of narrative elements from the narrative knowledge structure. Similar to the learning activity generation, each theme is associated to one or several root nodes in Time layer. For example, "Life style in ELC" is associated to the time element, "2011". The story generation engine first finds the root node, and then pulls out a series of child nodes and relevant nodes of its very next layer, i.e., the root nodes of Place layer. These narrative elements will be put into the candidate list as Figure 6 shows.

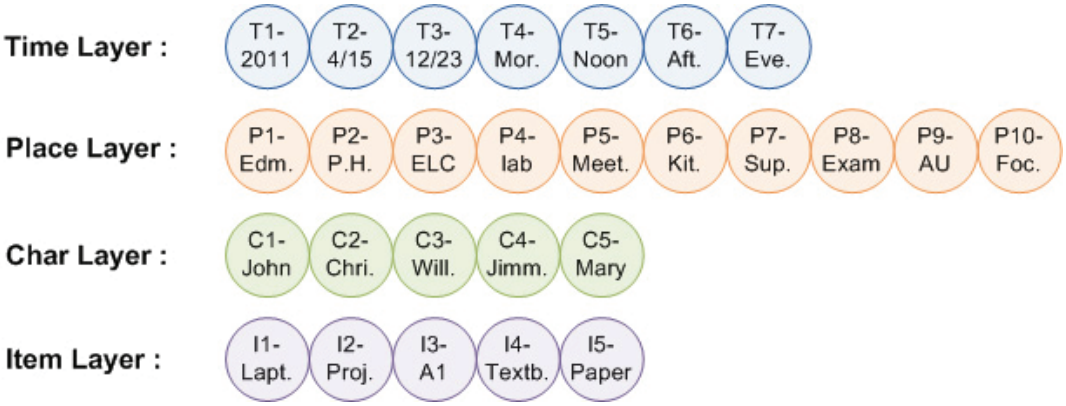


Figure 6: The candidate list of narrative elements

Once the story generation engine has the candidate list of narrative elements, the engine starts working on the plot generation from the story templates according to the amount of learning activities in the generated learning activity chain. Each plot may be formed with one single template (i.e., a whole story)

or with the composition of several templates. For example, the learning activity generation engine produces four learning activities for "Life style in ELC" as Figure 3 shows, which means the story generation engine should have at least four correspondent plots for decorating the chain with stories. Figure 7 shows the four plots the engine works out.

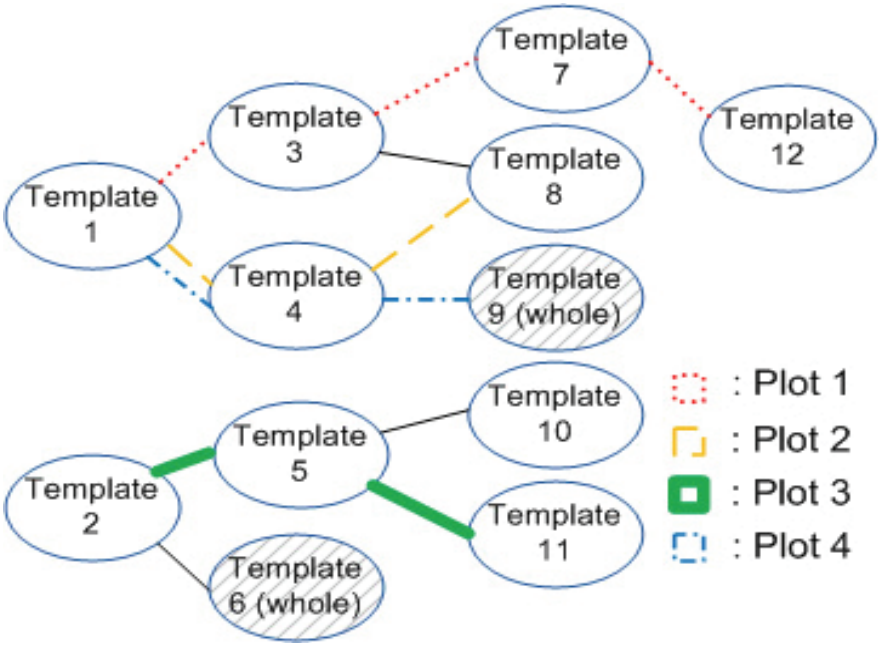


Figure 7: Story template tree and the four plots that the engine worked out

By expanding of the story template tree, the generated plots have diversified results. Furthermore, each story template has five properties include "Story Pattern", "Relevant Template", "Non-Repeatable Element", "Whole Story", and "Content". Story pattern property lists the required narrative elements of the story template; Relevant Template property states a list of template IDs which are the parent of the story template; Non-repeatable element property indicates which the element(s) included in the story pattern can be used only once; Whole story property tells whether the story template is a well-structured and self-contained story; and, Content property is the story context. Table 1 lists Template #7's property values.

Table 1: Template #7's properties

Template ID	7
Story Pattern	[Room][Male]
Relevant Template	<3>
Non-repeatable Element	[Room]
Whole Story	False
Content	In the [P1], [C1] is talking with [C2]. [C2] sees you come in and invites you to join the talk.

After the story generation engine worked out the plots, the next step that the engine needs to do is to fill up the chosen templates with the pre-selected narrative elements in the candidate list for decorating the learning activities and transforming the chain to a storyline. The step is called the filling and forming process. In the beginning of the filling and forming process, the story generation engine calculates the amount of required narrative elements and summarizes the story patterns for each plot. For instance, Plot 1 in Figure 7 covers four templates: Template #1, #3, #7, and #12. Each template has its own properties like Table 1 lists. Therefore, the engine can get the total amount of required narrative elements as well as the story patterns for filling up. Table 2 illustrates the calculation results for Plot 1.

Table 2: Calculation results for Plot 1

Template #1	Template #3	Template #7	Template #12
[Time][Building]	[Floor]	[Room][Male]	[Male][Item]
T=1; P=1; C=0; I=0	T=0; P=1; C=0; I=0	T=0; P=1; C=2; I=0	T=0; P=0; C=1; I=1
Plot Generation →	Plot 1		
Story Pattern	[Time][Building][Floor][Room][Male][Item]		
Amount of Elements	T=1; P=3; C=3; I=1		
Non-repeatable Element	[Room]		

As abovementioned, four filters are used by story generation engine to filter out the plot irrelevant or non-sense narrative elements in the candidate list. For instance, in Table 2, the generated Plot 1 asks the pattern of time narrative elements as "time" , which means the engine will not need the elements such as "year - 2011", "date - 4/15", and "date - 12/23" when it fills up the plot and corresponding templates. Similarly, the engine also doesn't need the elements such as "city - Edmonton" and "female - Mary" for Plot 1 either. The modified candidate list of narrative elements is shown by Figure 8.

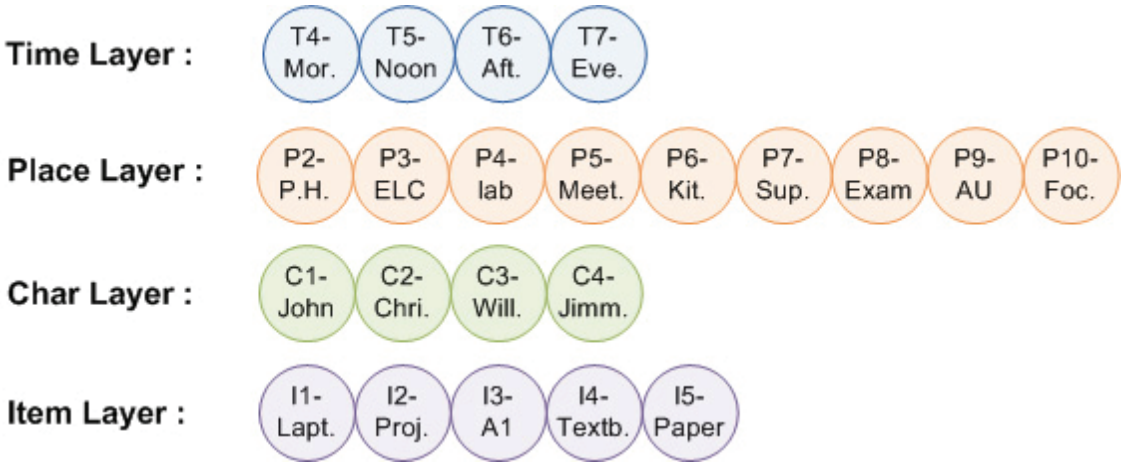


Figure 8: The modified candidate list of narrative elements

Next, the story generation engine starts using the narrative elements in the candidate list to fill up the plots. For instance, the four templates in Plot 1 compose a short story template as follows:

> *"Monday's [T1], [P1] is busy as usual. Today is my first time to [P2]. It would be great if I can make some friends there. [C1] told me that I should find [C2] in [P3] first. At that place, [C2] is using his [I1] and looks like he needs someone's help. He sees me coming in and says, 'Good to see you, I just need a hand to complete my task.'"*

This plot asks for ONE time narrative element, THREE place narrative elements, TWO characters, and ONE item. The four filters are used to check the amount of required elements. If the target plot only asks one element, then the engine just randomly picks up from the modified candidate list; on the other hand, the engine will consider the sequence between elements (i.e., morning goes before noon; 2011 goes before 2012, etc.), the limitation of repeatable elements (i.e., if the dragon was killed, it would not be used by the followed plots), and specific schema in the layer (i.e., actions and emotions in a character's schema) respectively. At the end, all plots are filled up with the modified candidate list of narrative elements and several short stories came out for decorating the learning activity chain as well as the game. Taking Plot 1's short story template as an example here to see what the engine has done and what an output story looks like:

> *"Monday's afternoon, Peace Hills is busy as usual. Today is my first time to ELC. It would be great if I can make some friends there. John told me that I should find Chris in meeting room first. At that place, Chris is using his laptop and looks like he needs someone's help. He sees me coming in and says, 'Good to see you, I just need a hand to complete my task.'"*

Once the story generation engine filled up all plots, the engine decorates the learning activities with these short stories and forms a storyline. Due to both learning activity generation and story generation are based on the user's chosen theme (for example, life style in ELC), the game can provide a meaningful and consistent storyline for the user.

6. The game-play with prototype system

A prototype system has been developed and is ready for using. Some mobile application design issues have been taken into considerations while developing the system, such as screen size, human-device interaction, computing capability and no additional devices (Lu, Chang, Kinshuk, Huang, and Chen, 2011). Here in this paper, we focus on decorating learning activities with story in the game-play. The game-play can be divided in six stages as Figure 9 shows.

When the user enters the game world in the very beginning, the game helps user to access the server to check out his/her learning profile (i.e., has played the game before and completed some themes before)

(as Stage 1 on Figure 9 shows). Next, the game offers two roles for the user chooses after successfully signed in (as Stage 2 on Figure 9 shows). The game gets user's theme choice and starts generating the learning activity chain. The story generation engine also helps to decorate the learning activities with short stories based on the narrative knowledge structure (as Stage 3 on Figure 9 shows).The user can enable the built-in camera and start working on the designated activities in the real world (as Stage 4 to 6 on Figure 9 show). At the end, the game judges if the collected item is what the learning activity asks for (as Stage 7 on Figure 9 shows).

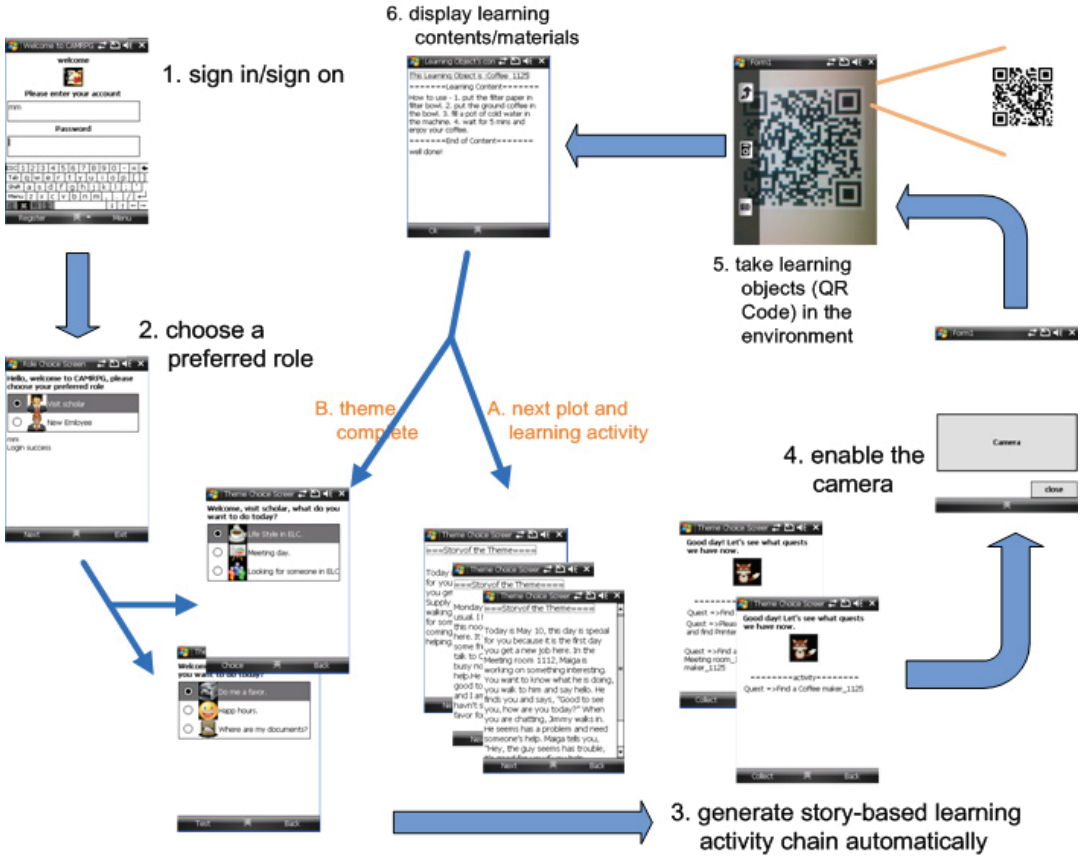


Figure 9: Screenshots of the game-play

7. Conclusions

In this paper, we present a context-aware mobile role playing game in which the kernel, learning activity generation engine and story generation engine, can generate a series of story decorated learning activities automatically. This game can help users learn by role playing in the authentic learning environment. The storyline makes up the learning activity chain and leads the learning process more interesting and immersive. The game generates story decorated learning activity chain automatically according to the context in the environment and user's preference and learning experience. The proposed game has several advantages and benefits to users. First, the knowledge structure is the fundamental of two engines and can be built up easily for any learning environment by anyone. Second, the story decorated learning activities give users story backgrounds which are consistent with the learning activities that they are going to do. The stories can make users feel that they are living at the virtual world and they have responsibility to help the NPCs to finish some tasks. The game still has a drawback in the current version, that is, since the storyline generation process is highly depended on the narrative knowledge structure, the stories used to decorate the learning activities may repeat some elements and story templates if the narrative knowledge structure is not large enough and/or was not well-designed in advance. At the last, the proposed game still needs a subjective experiment in order to know the users' attitudes and acceptance towards the story decorated learning activities as well as their learning outcome from the game-play.

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