Makahiki: A Serious Game Engine for Sustainability
A Research White Paper

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June 12, 2012

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Abstract

My research seeks to investigate how to build a customizable serious game engine for sustainability called Makahiki. It provides an open source, component-based, extensible framework for creating serious games for the purpose of education and behavioral change regarding energy, water, food, and waste generation and use. Different organizations configures the Makahiki framework to produce a "challange instance" with a specific set of game mechanics, user interface features, and experimental goals. Makahiki provides sophisticated instrumentation to support evaluation of how well the game mechanics supported the organization's goals for the challenge.

This white paper describes the Makahiki's research goal, system design, and experimental design on how to evaluate the effectiveness of the Makahiki as framework in developing serious games.

1 Introduction

Sustainability education and conservation has become an international imperative due to the rising cost of energy, increasing scarcity of natural resources and irresponsible environmental practices. Over the past decade, running energy and water challenges have become a focal point for sustainability efforts at university, government, and industry campuses. Designers of those competitions have had three choices for information technology: (a) build their own custom in-house solution; (b) out-source to a commercial provider; or (c) use a "minimal tech" solution such as a web page and manual posting of data and results.

We developed a framework called Makahiki as a new choice: an extensible game engine for the development and evaluation of sustainability challenges. Makahiki has a unique feature set intended to foster more rapid innovation and development. These features include: (1) an open source license and development model which makes the technology available without charge and facilitates collaborative development and improvement; (2) support for an "ecosystem" of extensible, interrelated, customizable games and activities; (3) real-time game analytics and A/B testing for research and evaluation; (4) pedagogically organized and extensible learning activities; (5) a responsive user interface supporting mobile, tablet, and laptop displays; and (6) support for deployment to the cloud as an inexpensive option for hosting the competition.

The Makahiki framework will be used in 2012 by three organizations, namely, University of Hawaii at Manoa, Hawaii Pacific University, East West Center of University of Hawaii, to implement individually tailored sustainability challenges.

2 Research Goals

There are two research goals in Makahiki: (a) provides an extensible framework to easily create engaging games for sustainability education and behavior change, and (b) provides an experimental test bed for Gamification research into the effectiveness of different game mechanics in the context of sustainability.

The challenges of creating a customizable game engine are: (a) creating a new instance of Makahiki by selecting the games they want the system to support, and (b) extending Makahiki by writing new game components, and (c) supporting ease of use by non-technical organizations with minimal technical support.

In order to provide an experimental test bed for game research, Makahiki will be designed to support A-B testing, where different game mechanics could be configured using the game engine to create "treatments" for different user groups. The game engine will provide real-time game analytics to these treatments.

3 System Design

Makahiki consists of a configurable game engine that can be customized to the needs of different organizations. It includes a library of pre-built game "widgets" that implement a variety of game mechanics. Using the widgets, an organization can create a custom energy challenge in which players can compete individually and/or in teams to earn the most points by reducing their energy consumption as well as by learning about energy concepts in general.

Figure 1 illustrates the architecture of Makahiki.

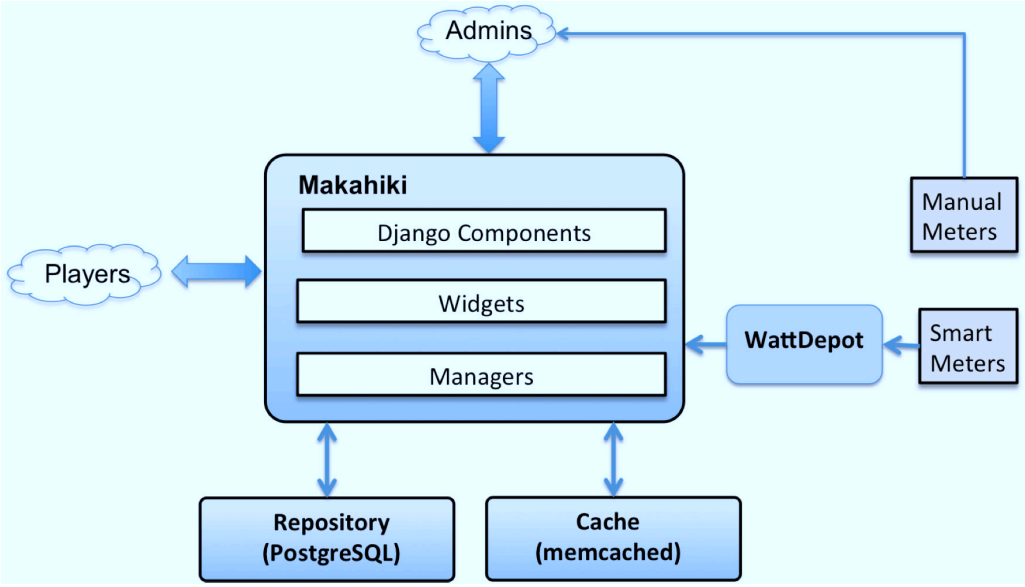

Figure 1: Makahiki System Architecture

4 Experimental Design

In order to evaluate how the Makahiki meets the research goals, we propose to investigate the following the research questions:

1. *Can Makahiki be successfully deployed in multiple organizational scenarios to provide games for major sustainability issues (energy, water, waste, recycling, transportation, etc.)?*
2. *Can Makahiki provide an API and procedures to support enhancement with new features and capabilities with a minimum of impact on other aspects of the framework?*
3. *Can Makahiki provide an engaging and fun learning user interface to its end users?*

4. *Can Makahiki provide a mean to perform research on games for sustainability through A/B testing?*

4.1 Site Admin Evaluation

To evaluate question (1), we plan to perform the case study research on multiple case studies. We call it "Site Admin Evaluation". It consists of surveys and interviews of administrators of all sites, asking for their assessment of the framework, whether it fulfilled their needs, and what they wish was different/better.

4.1.1 Post-challenge Survey

The survey will be sent out to the administrators of three sites, namely, University of Hawaii at Manoa, Hawaii Pacific University, and East West Center at University of Hawaii, right after their challenges are completed. The survey covers the topics of installation of Makahiki, configuration of Makahiki before the challenge, and the administrative tasks during the challenge.

The survey contains ** questions and we expect that the time to complete is about 10 minutes. The completed questionnaire follows:

1. Install the Makahiki locally is:
    - don't need to install locally
    - Very Easy
    - Easy
    - Neither easy nor difficult
    - Difficult
    - Very Difficult
2. Installing the Makahiki in Heroku is:
    - don't need to install in Heroku
    - Very Easy
    - Easy
    - Neither easy nor difficult
    - Difficult
    - Very Difficult
3. Please describe any problem you encountered during the installation, either locally or in Heroku:
4. How long does it take you to complete the installation of Makahiki:
    - less than 10 minutes
    - about 1 hour
    - about 2 hour

- more than 2 hours but less than a day
- more than 1 day

5. Configuring the Makahiki to your organization's needs is:
   - Very Easy
   - Easy
   - Neither easy nor difficult
   - Difficult
   - Very Difficult
6. How long does it take you to complete the configuration of Makahiki to run your organization's challenge:
   - less than 1 hour
   - about 2 hour
   - more than 2 hours but less than a day
   - more than 1 day
7. Please describe the most difficult part(s) of the configuration you've encountered while configuring the Makahiki:
8. Administration using the Makahiki admin interface during the challenge is:
   - Very Easy
   - Easy
   - Neither easy nor difficult
   - Difficult
   - Very Difficult
9. How much time do you spend in administrating your organization's challenge using the Makahiki admin interface every day:
   - less than 10 minutes
   - about 1 hour
   - about 2 hours
   - about 4 hours
   - more than 4 hours

4.1.2 Training Interview

Before the Makahiki is used, the site admins are offered technical trainings about the use of Makahiki. We will record the training times, and interview the trainees to about the usability of the system. The result of training will affect the result of survey evaluation described in the previous section.

4.2 Developer Evaluation Case Study

To evaluate question (2), we plan to perform the case study research on at least one case. We call it "Developer Evaluation Case Study". It consists of a "case study" of an external developer who is tasked with making an enhancement to the system. Careful records of his interactions with developers, commits, and self-reported issues and problems along with interview data is used to determine how well the system achieved its goal as an extensible framework. The goal for the developer evaluation is to find out: (a) What kinds of learnings must occur, (b) What kind of background is necessary from a developer to enhance the system, (c) What kinds of problems were encountered and how they were resolved, (d) What kinds of changes to the system could be made to address the problems.

4.2.1 Methodology

1. *Log Book*: We will create a google Form for the developer to fill out at the end of each programming session. The content of the form follows:

   - Date and Time this session begins
   - Length of the session (in minutes)
   - Development activities (coding, documentation, debugging, testing, etc.)
   - What was accomplished
   - What problems occurred
   - Please commit your code so that we have your latest changes.

   Figure 2 illustrates the google form used for Makahiki developer evaluation.

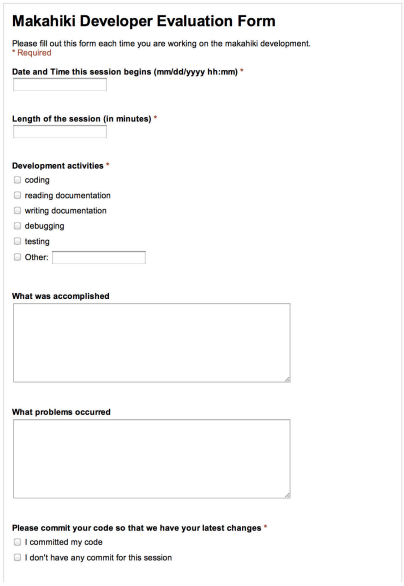

Figure 2: Makahiki Developer Evaluation Form

2. *Meetings* : We will have weekly developer meetings. we will record the meetings to support the analysis of development usability. we will focus on what kind of problems were encountered during the development.

3. *Emails and Chat sessions* : We will save the email exchanges with the developer and the online chat sessions for further analysis.

4.2.2 Data Collected

- time taken to setup the development env
- errors encountered
- interactions (emails, chats, meetings) with internal developers
- time spent in reading the doc initially
- time spent in reading the doc during the development
- time taken to create the initial revision of the enhancement
- time taken for unit testing, debugging
- time taken to integrate into the system
- number of makahiki APIs used
- commits, interactions in Github

4.3 End User Evaluation

To evaluate question (3), we plan to perform end users data collection and analysis using the framework itself. We call it "End User Evaluation". It consists of (a) in-game surveys of participants of all sites asking for their assessment of the game experience and its suitability to their situation; (b) aggregated analytics data from log files of all sites, providing insight into what parts of site were used in what ways.

4.4 A/B Testing Evaluation

To evaluate question (4), we plan to perform the case study research on at least one case. We call it "A/B Testing Evaluation". It consists of a "case study" of one A/B test performed in Fall 2012 in order to answer the following research question: What level of energy data "latency" is required to provide useful feedback to participants in energy challenges like the Kukui Cup? To assess this, we will implement three levels of energy latency in Fall 2012: (a) Subminute-level latency through the Power Meter at HPU; (b) Hour-level latency through the Daily Energy Goal Game at UH (no Power Meter); and (c) Day-level latency through the manual Daily Energy Goal Game (at EWC). In-game surveys can be used at each site to determine how much participants interacted with the given type of feedback, and whether they felt limited by the given level of latency.