Building Blocks for Mobile Games: A Multiplayer Framework for App Inventor for Android

by

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Abstract

Building Blocks for Mobile Games is a client-server multiplayer game-building-framework for the App Inventor for Android platform. The Building Blocks for Mobile Games multiplayer framework includes an App Inventor component and a Game Server running on Google App Engine. The client-side-component packages the complexity of web service calls, data transfer and game state management into a set of graphical code blocks that allow users without programming experience to create Android applications that can access the Game Server API. The Game Server provides basic functionality that can be used to create simple multiplayer games and message-passing applications, such as a multiuser bulletin board. The Game Server is also extensible and can be enhanced with custom modules which provide server commands that implement game logic, perform database operations, access third-party web services, and read RSS feeds. Custom modules were used with Building Blocks to develop a multiplayer card game, a variant of Bulls and Cows with a shared scoreboard, an application that accesses Amazon's book search API and a pair of applications for creating, managing and voting in polls. The clients for these applications are built entirely with the App Inventor graphical blocks language, which can be assembled into Android Applications. The custom modules that support the client programs average less than 50 lines of Python code.

Thesis Supervisor: Hal Abelson
Title: Class of 1922 Professor of Computer Science and Engineering

Acknowledgments

First and foremost, I need to thank my advisor, professor, former boss and fellow Google intern Hal Abelson for starting this project, keeping me on track throughout the course of my thesis work and offering his incredibly valuable advice throughout the process.

I also owe a debt of gratitude to the entire App Inventor team at Google. Special thanks to my manager and blocks editor hacking partner Sharon Perl, tech lead Mark Friedman, my always helpful desk neighbor, Liz Looney, the voice of reason in our cubicle, Ellen Spertus and my fellow interns Ben Gleitzman and Jill Dimond. Finally, thanks to Alfred Spector for all his help in securing my continued role on the App Inventor team during the writing of this thesis.

Additional thanks are due to Ben for going through all four years of MIT with me. While living together and bushwhacking through the new MIT computer science curriculum there was never a dull moment. It has been great.

I wish everyone involved and App Inventor itself the best of luck in the future. A lot of very intelligent people are hard at work on this project and I fully expect it to make waves in the years to come.

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Chapter 1

Introduction

The increased prevalence and sophistication of mobile devices has created an exciting range of possibilities for mobile applications and games. In Europe and North America, smart phone ownership is on the rise and even most teenagers now own mobile phones[13]. The spread of this technology creates great opportunities to build mobile applications that enhance productivity, supplement learning, provide entertainment and connect people to information wherever they are. However, most of these users are left at the mercy of a relatively tiny population of sophisticated developers for the applications that they want. People are unable to create programs that are customized for their own life or implement the great ideas they have for programs because the process of building them is extremely difficult and requires background knowledge of Computer Science topics.

Computer games have been used in classrooms to provide motivating examples and give students an exciting avenue for instruction[9]. Unfortunately, the complexity of building computer games often creates an insurmountable barrier for introductory students. Mobile games, on the other hand, do not suffer from this shortcoming because much of their entertainment value derives from interaction with others rather than advanced graphics or quick gameplay. Web enabled mobile phones provide the capability to make programs and games with real time interaction that can replace the complex game characteristics seen on platforms such as video game consoles and desktop computers[2]. Enabling users to interact

with each other using their phones provides even more room for application ideas to grow.

Typically, multiuser games consist of a single server and a large number of clients[12]. Unfortunately, the complexity of client-server interaction with mobile devices makes creating multiuser applications very difficult. To address these issues and empower mobile phone users to create social applications and games, I created the Building Blocks for Mobile Games multiplayer framework for App Inventor for Android. Building Blocks for Mobile Games includes an App Inventor component with a suite of client-side operations that communicate with a Game Server in order to create and play games. With these operations, users of App Inventor can create mobile applications to communicate and coordinate with each other, access external web services, perform computation in the cloud and maintain game and user state online.

1.1 App Inventor for Android

The client-side of Building Blocks for Mobile Games is implemented specifically for the App Inventor for Android system, a project currently underway at Google Research[1] that aims to turn mobile phone users into mobile application creators. App Inventor builds on previous work done on graphical programming languages such as StarLogoTNG[10] and the Openblocks library[11] to provide an application development framework that gives users without coding experience the ability to create mobile applications.

In the fall 2009, App Inventor was used in a pilot program at a dozen universities[1] as a tool to help teach students about a range of topics related to computer science, digital privacy and the importance of technology in society. During the semester, students created a variety of simple phone applications and explored some of the difficulties of developing on a mobile platform. Following this pilot program, Google Research has continued to work on App Inventor as more classes have started to use it in the spring.

App Inventor works by packaging the complexity of user interface widgets and phone hardware features into easy-to-use components. The functionality of components are exposed to application developers via graphical code blocks, instead of with written code. Just like putting together a puzzle, users of App Inventor can snap together blocks to create mobile phone applications without the need to write code or understand the complexities of deploying applications.

1.2 Games in App Inventor

Existing App Inventor components focus on local application behavior such as the appearance of on-screen components and direct user input. Programs generally consist of a single screen and have little ability to interact with other programs or access functionality outside of the device. Building Blocks for Mobile Games widens this focus by creating a Game Client component and a Game Server implemented using Google App Engine. The use of App Engine as a server platform allows application developers to easily customize and deploy their own servers. A Game Server is hosted by Google for application creators to use as a testing and development environment. However, given that the process of starting and customizing one's own server is reduced to the execution of a Python program when using App Engine, it is expected that most application developers will deploy their own servers.

The Game Client component follows the pattern of existing App Inventor components by packaging code to perform procedures or to handle program events into graphical blocks which can be used by the program creator to create applications. When the Game Client's blocks are used to call procedures, the component sends requests using the phone's mobile data connection to the Game Server[1]. Additionally, data that dictates the flow of a game and its list of players is automatically processed by the client to provide the application with helpful events such

[1]The marshalling and unmarshalling of data into formats that can be understood by both App Inventor and the web server are automatically handled and invisible to the user.

as when a player enters or leaves a game and when an invite to join another game has been received.

Without modification, the Game Server provides a default implementation that includes basic game management, message handling, and access to built-in extensions such as a scoreboard and a card game manager. The BulletinBoard application shown in Section 5.1 demonstrates an application created using the unmodified server deployment. However, the ability to add custom behavior to the Game Server is very important because the client-side component can only be modified by changing the production App Inventor servers run by Google. Thus, to allow applications to access external resources and functionality which is not available in App Inventor, the Game Server was built to provide extensibility through custom modules that can be added to a Game Server installation and accessed with the Game Client component.

During the pilot program, a web database component called TinyWebDB was provided to students along with its server source code. During the semester, a number of students modified this server code to overload the database's simple get and put commands. A class at Wellesley, even worked with the Google team to create a custom component that allowed applications to access a server that implemented a voting application[2]. This process involved many hours of effort and hundreds of lines of code to both create a custom component to serve as a client and to implement the needed request handlers and database models on the App Engine server. This is not only a laborious approach, it is impossible for most users because creating a new component in App Inventor requires modifications to production Google services. Chapter 3 walks through a reimplementation of the voting application built at Wellesley. The new version requires only that a single Python file with less than 100 lines of code be added to the Game Server. On the App Inventor server, no new components or other modifications are needed.

[2]The course, CS 114 - Technologies for Communication was taught in the fall of 2009 by Professors Takis Metaxas, Eni Mustafaraj and Lyn Turbak. The custom component was created primarily by Prof. Mustafaraj.

1.3 Thesis Summary

Chapter 2 provides an introduction to the App Inventor system. Chapter 3 is a walkthrough of the creation of a voting application. An in-depth look at the Game Client component and the server API are given in the system overview in Chapter 4.

After the system overview, Chapter 5 describes four other example applications that I have built to demonstrate the various use patterns of the Game Client component and Game Server:

- Bulletin Board - A multiuser online message board which was created without any modifications to the Game Server.
- MoBulls and Cows - A version of the classic pen-and-paper game Bulls and Cows which implements game logic in a custom module and uses the Game Server to maintain a high score list among all players of the game.
- Amazon - A book lookup application which accesses Amazon's E-Commerce Services with a custom module.
- Androids to Androids - A multiplayer card game which shows players simultaneously participating in a multiple round card game with score keeping.

Then, Chapter 6 presents other work in the areas of graphical programming and mobile game creation. Chapters 7 and 8 discuss possible future extensions to Building Blocks for Mobile Applications and list the contributions of this thesis.

Chapter 2

Introduction to App Inventor

This chapter gives an introduction to the two-part process for building Android applications in App Inventor. First, application creators design their user interface with the application designer, which is run in a web browser and hosted by Google's App Inventor server. Then, creators must define the program logic in the App Inventor blocks editor. To use the Building Blocks for Mobile Games multiplayer framework, users simply include the game client component in their App Inventor project and use the component's blocks to make calls to the Game Server running on App Engine.

The App Inventor server, which runs the application designer, also contains the component code and compiles user projects. These pieces all work together to enable users to easily design, build and package applications that can run on any Android phone.

2.1 The Application Designer

The first step in creating an App Inventor project is to add components and lay out the user interface using the application designer. Figure 2-1 shows a blank application designer window running in a web browser. On the left is the component palette showing a collection of basic user interface components such as buttons, labels and text input boxes. Users add components to their projects by dragging

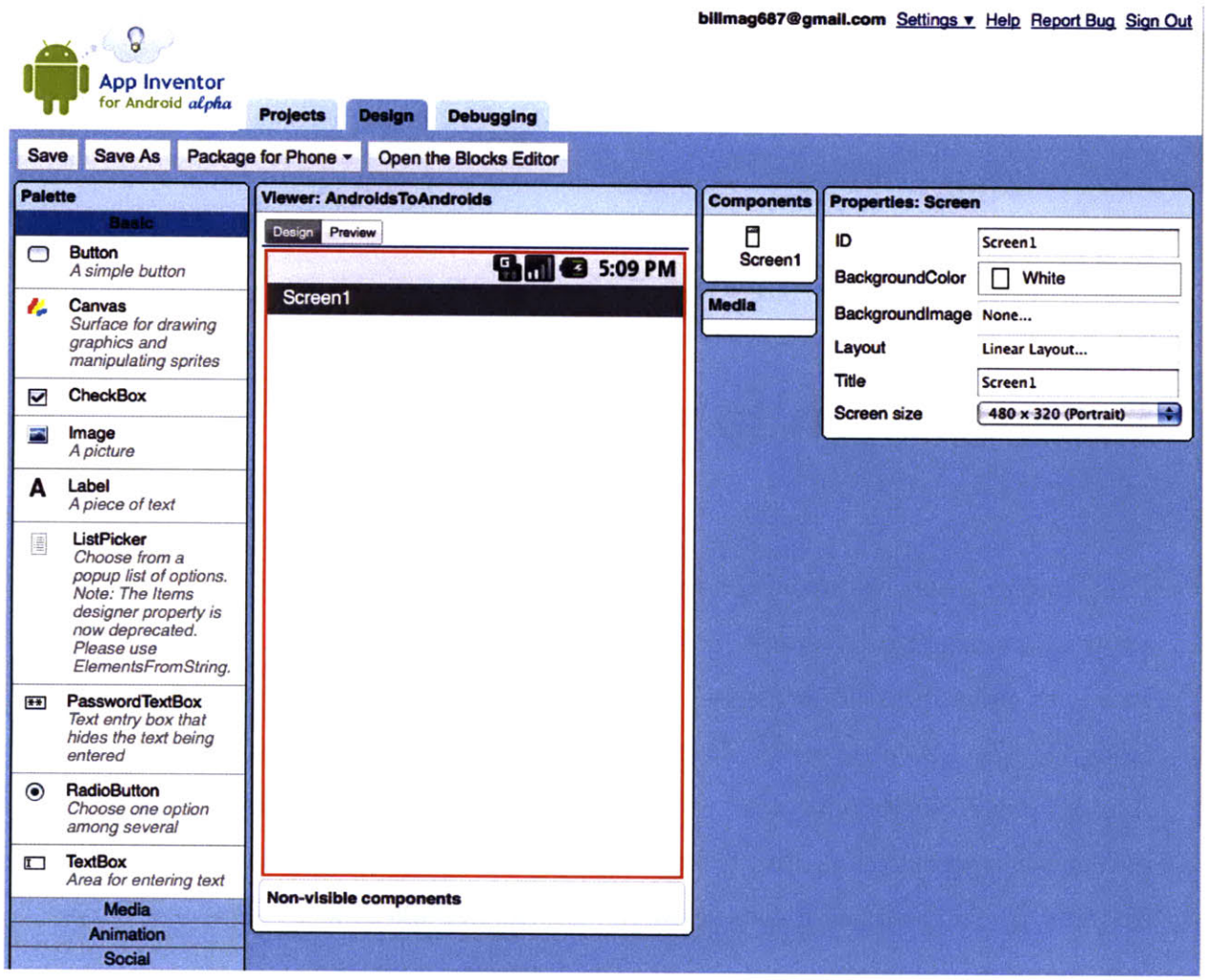


Figure 2-1: An empty application designer window. The application designer is just one part of the App Inventor web interface. The tabs visible across the top provide access to project management, sharing and debugging features. Additionally, the buttons above the viewer are used to package and download applications as well as to open the blocks editor (see Figure 2-4).

them from the palette on the left to the viewer in the middle. Figure 2-2 shows a completed user interface design for a web enabled bulletin board program.

The application designer allows users to define both the layout and the initial attributes of their components. Whether a property is allowed to be changed is determined by the creator of the component. Component configuration can include both aesthetic and behavioral properties. As an example, the properties panel for a button is shown in Figure 2-3.

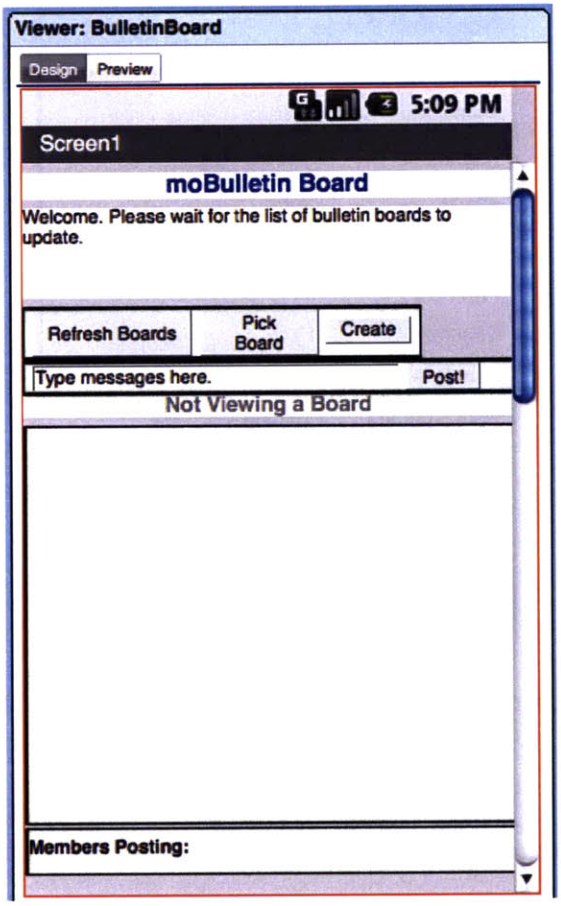


Figure 2-2: The completed user interface of a simple application for joining shared bulletin boards and posting messages for other users to see.

2.1.1 Non-Visible Components

In addition to the user interface widgets, the designer also includes non-visible components. Each non-visible components falls into one of the following categories:

- Sensors - Include all components that access phone hardware features such as the GPS or accelerometers.

- Notifiers - Are capable of popping up alerts or writing to the phone's activity log. Notifier components are generally not visible at startup, but can contribute to the user interface through the form of text input dialogs or other popups.

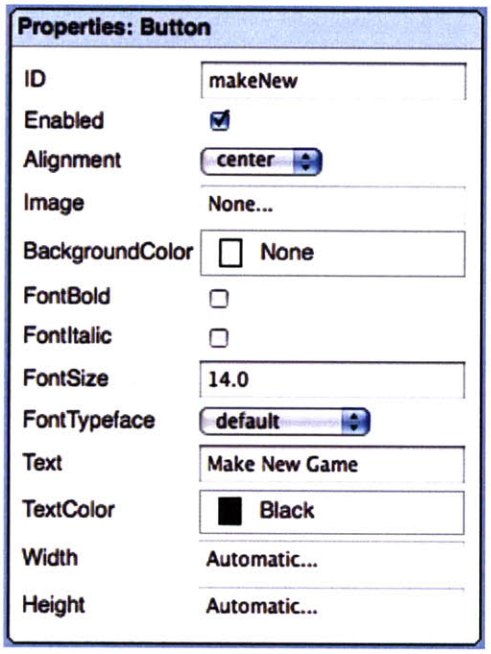


Figure 2-3: The configurable properties for a button component shown in the application designer.

- Clocks - Provide access to time related functions and a timer that can be set to periodically trigger events.

- Activity Starters - Allow a program to start or use other installed applications on the phone. Some examples include the barcode scanner and text to speech components.

- Web Services - Include the Game Client component, a web database with simple put and get operations, a Twitter component and the original Voting component.

The Game Client component includes blocks for completing requests to the Game Server. When a call is made using the Game Client, a new connection is opened to the Game Server and a POST request is made. The Game Server reply is interpreted by the Game Client and used to update its own properties or trigger events related to the game.

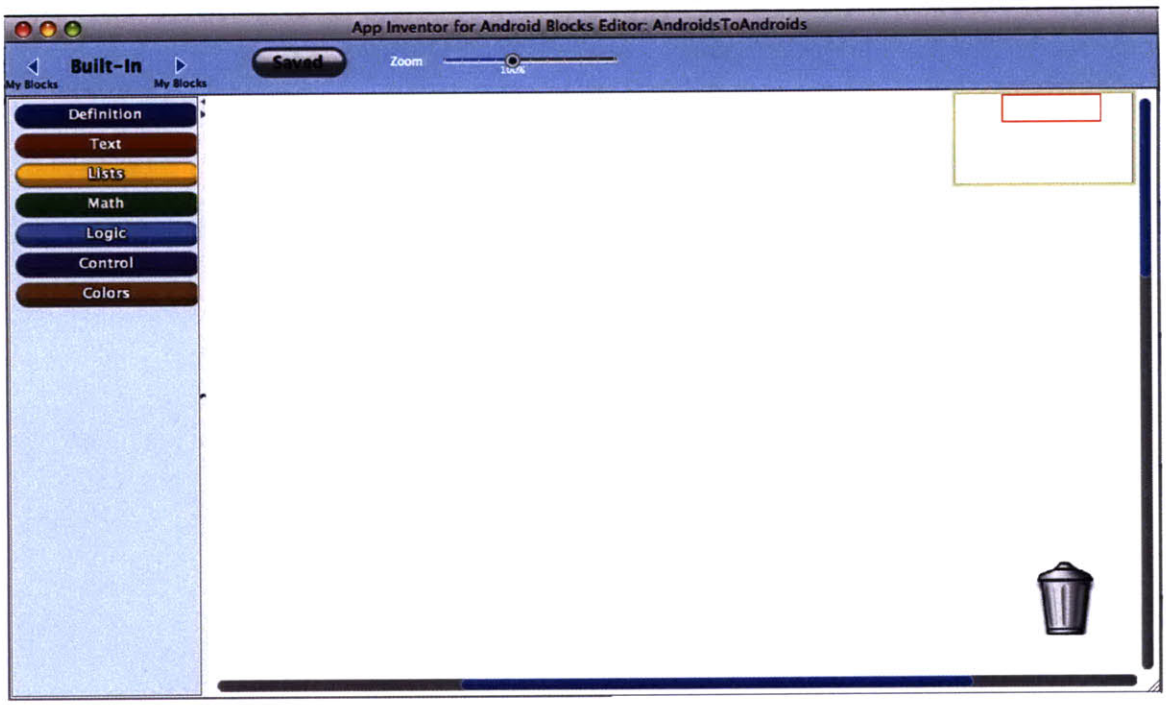


Figure 2-4: An empty blocks editor. To build an application users select blocks from the panel on the left and drag them into the workspace.

2.2 The Blocks Editor

After all the components for a project are selected, users must create the programming logic for their programs in the blocks editor. An empty blocks workspace in the blocks editor is shown in Figure 2-4.

The blocks editor combines related code blocks into drawers. Users can drag blocks from these drawers into the workspace in order to add them to their projects. Built-in drawers such as the one seen in Figure 2-5 provide the programming primitives that are used to create applications. These primitives are split up into categories based on their purpose. For example, text blocks are used to operate on strings while math blocks provide functions that operate on numbers.

An important abstraction capability in App Inventor is the ability to define procedures and variables which can be called from procedures and event handlers. The blocks to create these are in the definitions drawer.

Finally, each component has a drawer with all of the blocks defined for it by the component creator. The blocks in a component drawer come in four flavors: event

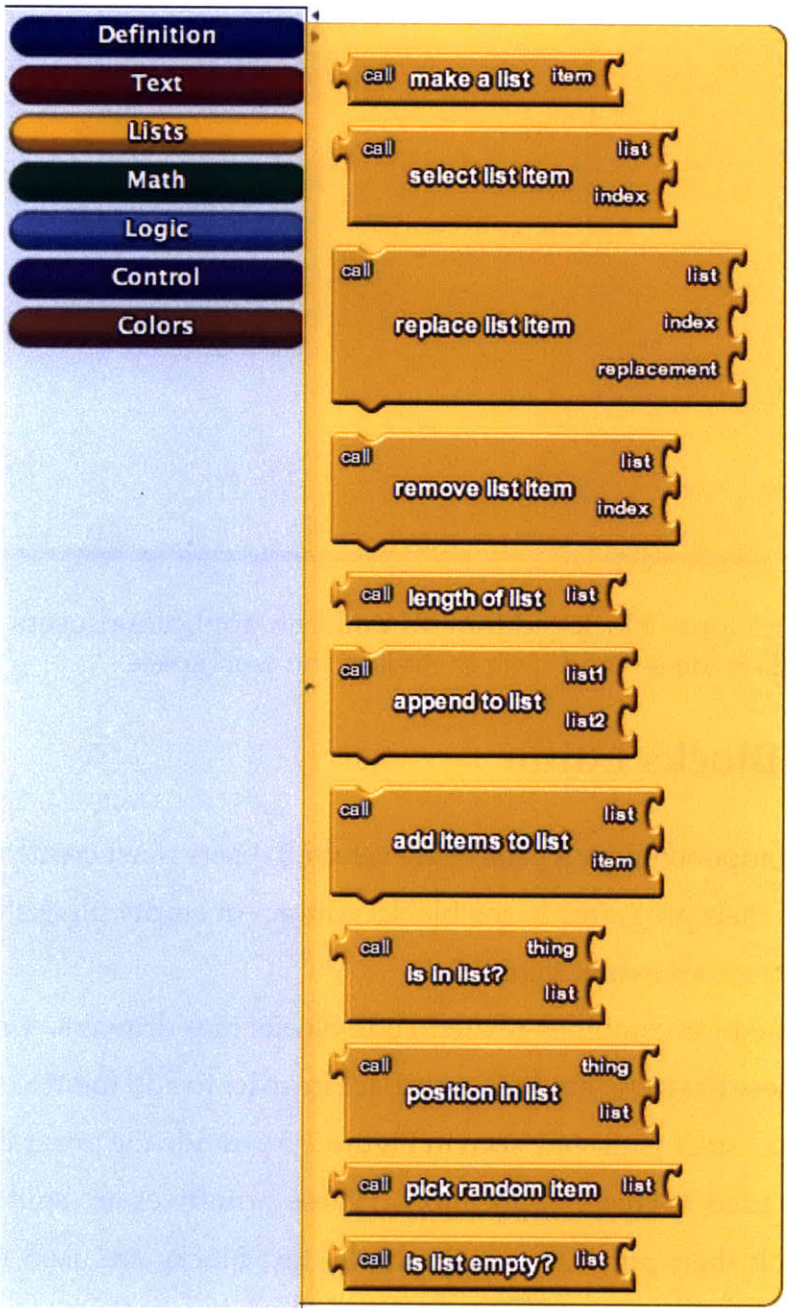


Figure 2-5: The built-in block drawer for list handling operations. Blocks that return values are shown with plugs on their left while blocks that modify existing structures have the call decorator and have dips and bumps on their tops and bottoms so that they can be strung together as a series of operations.

handlers, method call blocks, property getters and property setters.

2.2.1 Property Getters

Property getter blocks have a plug on their left side and return the value of various readable properties of components. Generally, these values are simple field getters, but in some cases they actually hide complex operations. The GPS getters on the Location Sensor component are a good example of this. To the user in App Inventor, the process of accessing the GPS is just as easy as reading the text of an input box. Abstracting this process ensures that users are not bogged down by the complexity of accessing information.

2.2.2 Property Setters

Figure 2-6: The property setter for the text of a button. Property setter blocks have sockets on their right side, which can be filled with the plug of a property getter or value block.

Property setters change the properties of a component to the value represented by the blocks that are plugged in the sockets on their right side. These sockets are shaped like the plugs on property getter blocks to indicate that they can be snapped together.

2.2.3 Event Handlers

Events are triggered whenever an event such as the click of a button, the return of a server call or a change in the accelerometer values occurs during the course of operation of a program. The body of an event handler block defines the actions to be taken when the event occurs. Figure 2-7 shows an event handler for a button that pops up a text input dialog when the button is clicked.

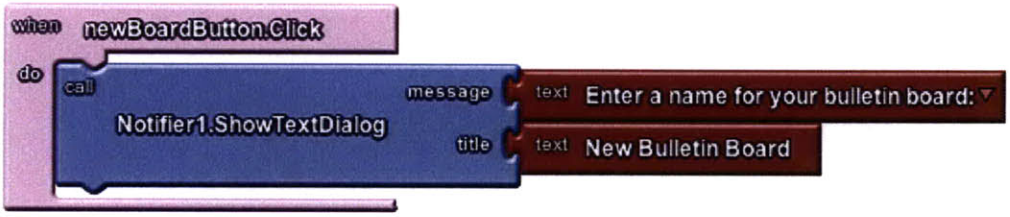


Figure 2-7: An event handler for a button that pops up an input dialog when clicked.

2.2.4 Method Calls

Method call blocks can be used in both user defined procedures and event handler bodies to define appropriate responses to events. These blocks encapsulate component operations and generally trigger further events in the process. The ShowTextDialog block in Figure 2-7 is an example of a method call that receives two arguments. The arguments are passed to the component to define the appearance of the text input box that is created.

Method call blocks have dips and bumps on their tops and bottoms to indicate that they can be stacked on top of each other. These blocks do not return values as programmers might expect a method to. This is made apparent visually by the lack of a plug on the left side of the method call block.

2.3 Overview of Building Blocks for Mobile Games

The Building Blocks for Mobile Games multiplayer framework consists of a non-visible Game Client component, a Game Server running on App Engine and utility classes in App Inventor which perform web service calls and convert data between App Inventor types and a format that is understandable to a server. Every application that uses the Game Server must include a Game Client component and use the method call blocks to make server requests. The basic architecture of this system is shown in Figure 2-8.

The Game Client includes built-in method call blocks which make requests to perform actions such as joining game instances, inviting new members, sending

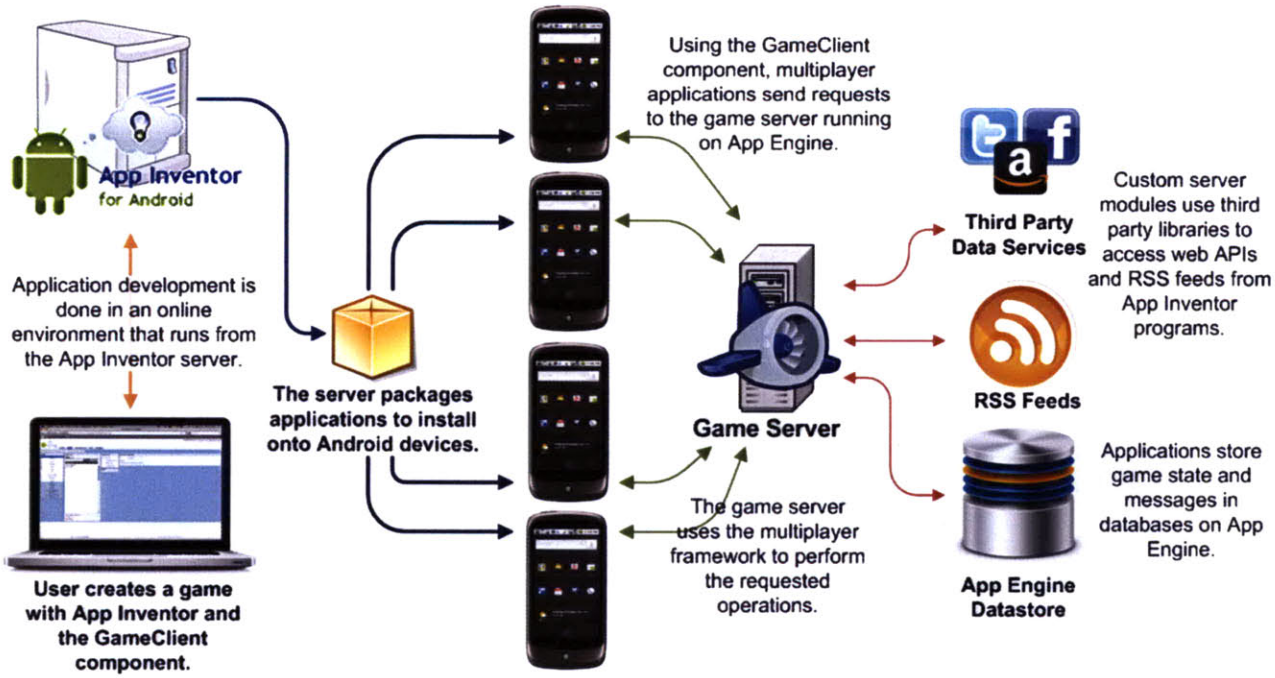


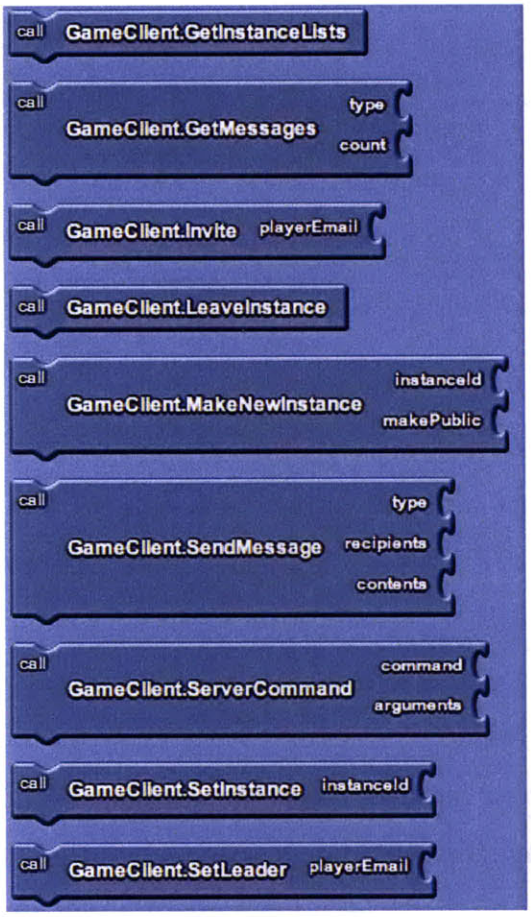
Figure 2-8: The architecture of App Inventor for Android with the Building Blocks for Mobile Games multiplayer framework.

messages to other players and executing custom server commands. The method call blocks are shown in Figure 2-9 (a). The Game Server defines a request handler for each of these actions which accept POST requests from the Game Client and reply with JSON objects containing the result of executing the server command.

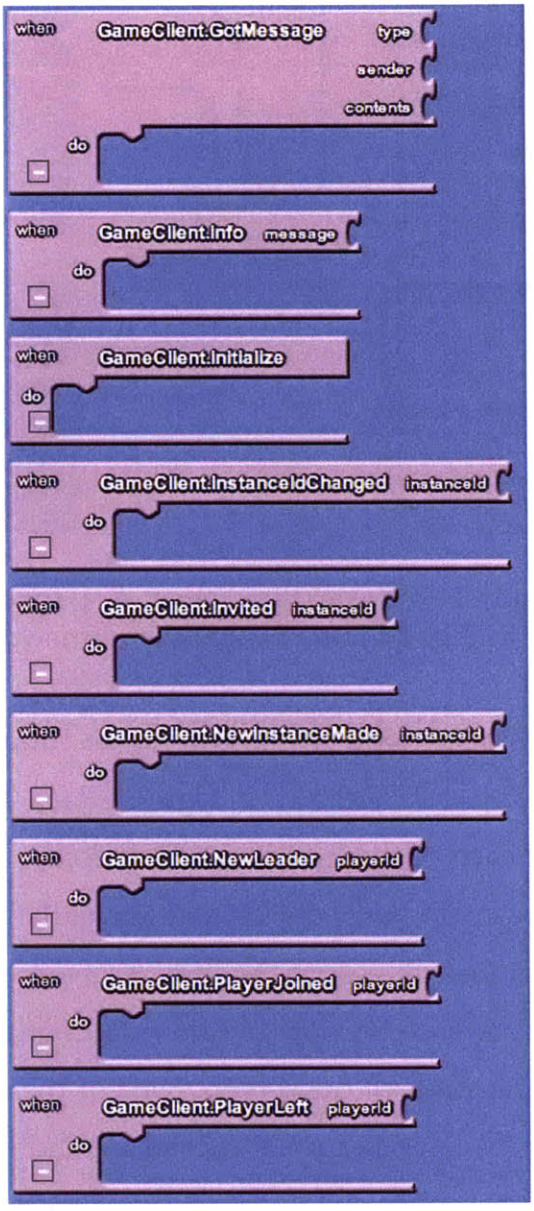
When the server reply is received, the Game Client processes it and triggers events based on the result of the request, and in response to any changes to the game state on the server. Nine of the event handler blocks are shown in Figure 2-9 (b). NewLeader, PlayerJoined and PlayerInvited events occur when the game state changes on the server. GotMessage triggers for each message received after a GetMessages method call block is executed. Chapter 4 provides a detailed description of the method call blocks, server API and event handlers of Building Blocks for Mobile Games.

To store data, the Game Server uses the App Engine data store. Information about games is organized into three levels:

- Game - Each application has one Game object in the data store which is iden-



(a) The method call blocks for the Game Client component. Each block makes a request to the Game Server and processes the result to trigger appropriate events.



(b) A selection of Game Client event handlers. Events are triggered to indicate that game state has changed or to provide useful information from server responses.

Figure 2-9: The method call and event handler blocks for the Game Client component.

tified by the game ID property of its Game Client component. The game ID operates as a namespace, allowing each application to maintain its own set of GameInstances. Game objects are also used to perform queries related to GameInstance objects such as finding the list of instances that a player has joined or been invited to.

- GameInstance - A GameInstance represents a group of players participating in a single game. A Game object can have any number of GameInstance children, but each GameInstance must have a unique instance ID among its siblings. Together, the game ID and instance ID uniquely describe a GameInstance object.

- Message - Message objects are used to send information from one player to another in a GameInstance. Messages can be created in App Inventor by using the SendMessage method call block or created by the Game Server inside of custom server commands.

In addition to the method calls and event handlers, the Game Client provides read access to its properties including the list of players currently in a game instance, lists of instances the current player has joined and been invited to, and the email address of the current player. These property blocks are shown in Figure 2-10.

The Game Server can also be augmented with custom modules written by application creators that define server commands to be called with the Game Client's ServerCommand block. These custom modules have full access to the App Engine database and can use third-party libraries and data sources to give programs access to outside information or execute complicated game logic.

2.4 Packaging and Running the Application

Once the application is designed and its blocks have been defined, it needs to be packaged by the App Inventor server into an installable application. The user

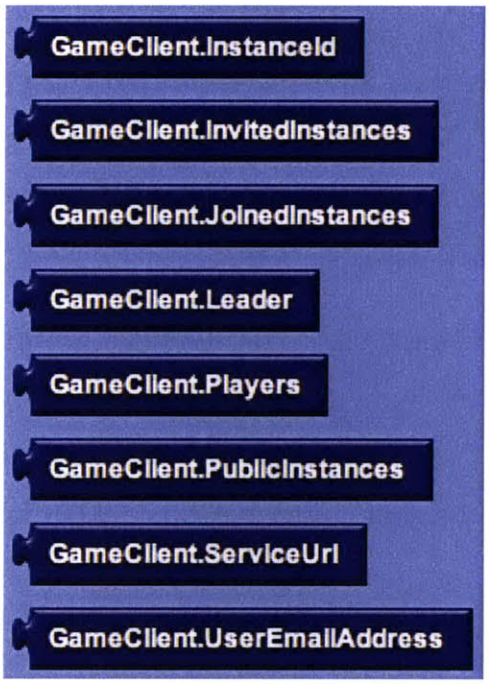


Figure 2-10: The property getter blocks for the Game Client component. The properties provide access to information about the current configuration of the Game Client component, and the state of the current game instance.

kicks off this process by clicking on the Package button in the application designer (Figure 2-1). The App Inventor server then orchestrates the saving, compiling and building of the project. Ultimately, the server delivers a fully functional application that can be installed on any Android phone and shared with friends.

Chapter 3

Building a Game

This chapter explains the process of building a multiuser voting application called Mobile Voting using Building Blocks for Mobile Games and App Inventor for Android. The chapter starts with a presentation of the user interface design, moves to a discussion of the custom server module and finally shows the blocks that make up the client. A voting application is uniquely suited to demonstrate a multiplayer framework because it uses interaction with others to derive enjoyment and utility. Mobile Voting consists of three parts:

- Ballot Box program - Displays polls to users and allows them to submit votes. Once a user has voted in a poll or the poll is closed by its creator, the vote counts for each option can be viewed.

- Poll Creator program - Allows users to create new polls for others to vote on. Poll creators can also view the vote counts in their polls, close them to new votes or delete them entirely.

- Voting custom server module - The server module is a python file running on the server, which defines seven different server commands. These commands can be invoked by the Game Client component by using a method call block.

With Mobile Voting, users can create polls using the Poll Creator on their Android phones. These polls are uploaded to the Game Server and stored in the App

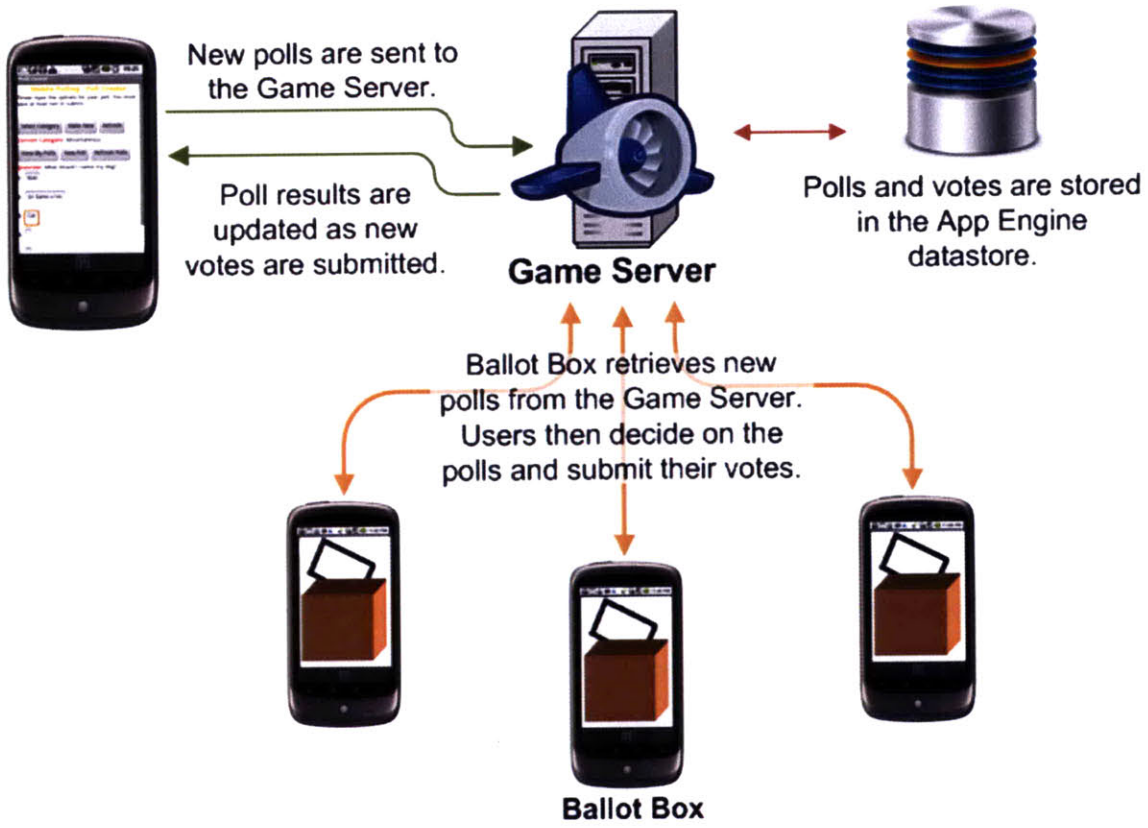


Figure 3-1: The process of creating and voting on polls with Mobile Voting.

Engine database. Other users can then use the Ballot Box program to vote on polls that have been made by others. Both the Ballot Box program and the Poll Creator program are created entirely using App Inventor with the Game Client component. The processes of creating polls and casting votes are shown in Figure 3-1.

3.1 User Interfaces

In order to simplify the user interface, Mobile Voting splits poll management and voting into two separate Android programs[1]. The user interface for each program is shown in Figure 3-2. Together, the two programs provide a user with the ability to do the following:

[1] App Inventor currently limits projects to a single form or user interface screen. This means that a two form application must be installed as two separate programs. This is likely to change as App Inventor matures as a platform.

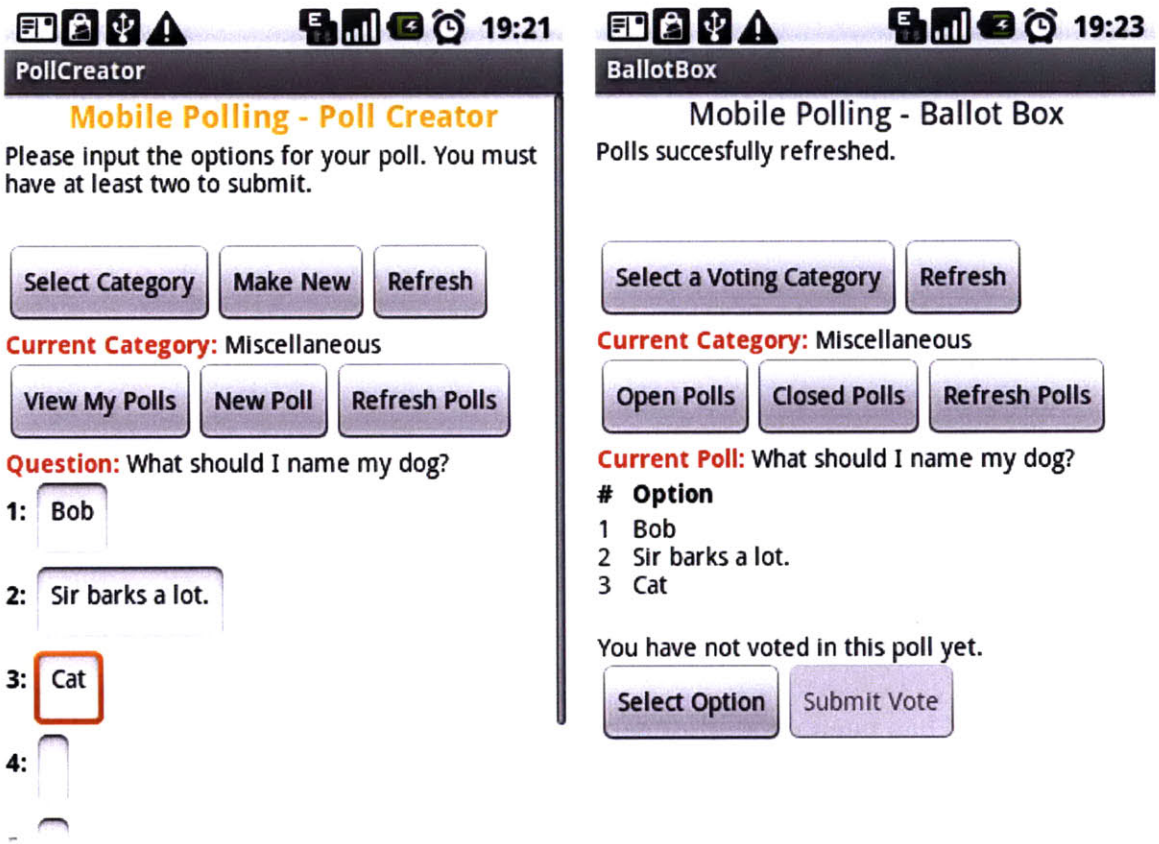
- Create new categories for polls.
- Create new polls by defining a category, a question and between two to five response options.
- Close and delete his or her own polls.
- View real time results of his or her own polls.
- View polls created by other users.
- Vote in open polls.
- See the results of polls he or she has voted in.
- View the results of closed polls.

Once a poll has been created, it can be viewed and voted on by others. Users are uniquely identified by the email account that is registered with their Android phone and disallowed from voting more than once in the same poll. Similarly, poll ownership is tracked by recording the email address of the poll creator.

After a user has voted in a poll, he or she is allowed to view its current vote totals but not change his or her vote. When the poll is closed by its creator, all users are allowed to see the final vote counts until the poll is deleted. Figure 3-3 shows the screens for viewing vote totals in both the voting program and the poll creator program. The owner of a poll can close or delete it by pressing the buttons below the options list.

Polls are split into different categories depending on their subject. All of the polls hosted on the demonstration server are made public, so that any player may join them. Players select from available lists and categories by using a component called a ListPicker. ListPickers appear on the user interface as buttons. When pressed, they display a list of strings and allow the user to select one.

The screenshots also show a number of disabled buttons. A button's state changes during program operation to define allowable actions. An example is seen in Figure 3-3 (b), where the "Submit Vote" button is disabled before a user



(a) The Mobile Voting Poll Creator. This screenshot shows the process of creating a new poll. The user has selected a poll category and defined his or her question. After submitting the poll to the server, it will be available for others to vote on.

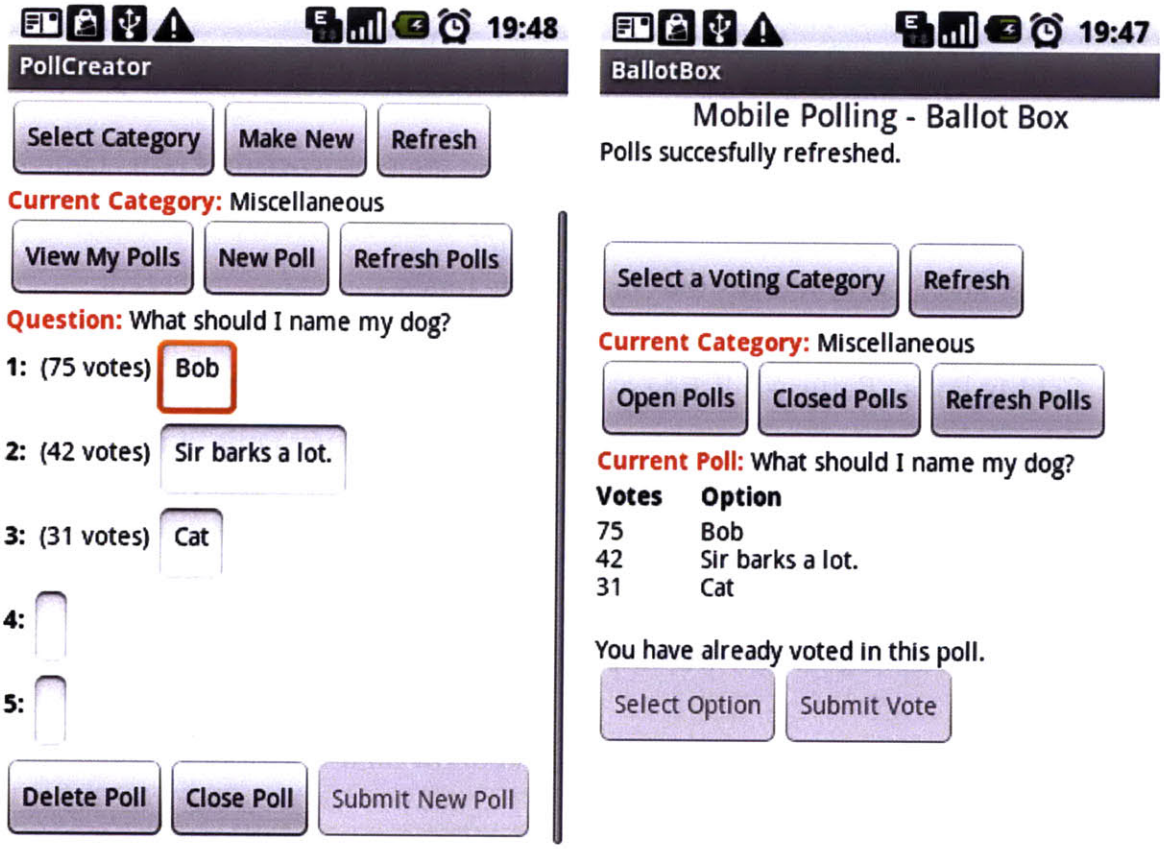
(b) The Mobile Voting Ballot Box. The user has selected the newly created poll and is ready to vote on it. The "Submit Vote" button will become enabled once the user has selected an option.

Figure 3-2: User interfaces for poll creation and voting.

has selected an option. This keeps the user from accidentally submitting an empty vote to the server. (As a backup, the server module has been written to deal with incorrect user input, but it improves usability to direct the user's behavior in the client as well.)

3.2 The Voting Server Module

The voting server module is a Python file written for the Game Server that defines seven server commands in approximately 75 lines of code. The code for this



(a) Poll creators can view the vote totals for their polls at any time and are allowed to close and delete their polls.

(b) When a user selects a poll from the list of open polls the server will check to see if he or she has voted in that poll.

Figure 3-3: Viewing vote totals on both the poll creation and voting screens.

module is shown in Code Listing A.13. Two of the commands are used by the voting program and the remaining five are used by the poll creation program. The commands are as follows:

- Get Results - Used by the voting program to request information about a poll's status and see if the user has already voted in it. While the client is waiting for the request to complete, the "Submit Vote" button is disabled. If Get Results responds without the poll results, the client knows that the user is allowed to vote and re-enables the button.

- Cast Vote - Submits a vote from the voting program. This command confirms that the requested poll is still open and that the player has not yet submitted

a vote before recording it into the database. It then returns the current poll results to the client.

- Get Poll Info - Returns detailed information about a particular poll. Unlike Get Results, this can only access polls that were created by the requesting player and always returns the current vote totals.

- Get My Polls - Returns a listing of all polls created by a player in a particular category. This listing is used to populate the "View My Polls" ListPicker in the poll creator program. When a user selects a poll from this list a Get Poll Info command is sent to retrieve more information.

- New Poll - Creates a new public poll for others to vote on.

- Close Poll - Closes polls to new votes and allow all users to see the final vote counts.

- Delete Poll - Purges a poll from the server and removes its vote history.

3.2.1 Server Commands in the Game Client Component

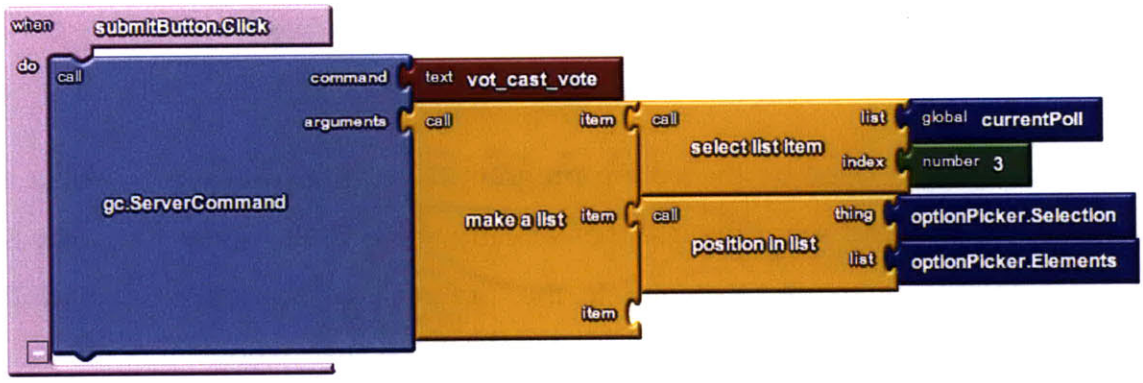


Figure 3-4: When a user hits the "Submit Vote" button in Ballot Box, a request is made to invoke a Cast Vote server command. The arguments to the command are the poll ID number, which is accessed from the currentPoll global variable, and the index of the selected option.

Requests to execute server commands are made by using the Game Client component's ServerCommand block. The server command block accepts two parameters:

- Command - The key for the requested server command. The Game Server uses a map of server command keys to custom module functions[2] to find the requested function and invoke it with the custom arguments defined in the second parameter.
- Arguments - A list of arguments to pass to the server command. The makeup of the list of arguments varies by command. This generic handling of arguments allows for server commands to accept any number of arguments of different types without modifying the Game Client component.

An example of a ServerCommand block being used to execute the Cast Vote server command is shown in Figure 3-4.

3.2.2 Defining Server Commands on the Game Server

On the Game Server, every server command must accept three parameters: a database model, the email address of the requesting player, and a list of arguments. Generally, server commands expect to receive a GameInstance database model. The Game Server uses game instances to represent a particular subset of a game's players and to serve as a parent for messages passed to members of that instance.

The voting module uses game instances to separate its polls into categories. As mentioned before, these instances are made public and allow an unlimited number of players to join them. However, game instances can also be made private and limit their membership to a particular number of people or only those who have been invited.

The code for the Make New Poll command is shown below. It first validates the inputs to make sure the question is not empty and an acceptable number of

[2]This map is explained in more detail in Section 3.2.5.

options has been provided. The procedure then initializes a Message object with an empty recipient and stores it in the database. [3]

3.1: The voting module's server command to create a new poll. (Excerpt from A.13)

```
1  def make_new_poll_command(instance, player, arguments):
2    """ Make a new poll.
3
4    Args:
5      instance: The game instance to add the poll to.
6      player: The email of the player creating the poll.
7      arguments: A two-item list containing the question and a
8        second list of 2-5 options.
9
10   Returns:
11     Returns a list with information about the poll just created.
12     See get_poll_return_list for its format.
13
14   Raises:
15     ValueError if the player is not in the instance.
16   """
17   instance.check_player(player)
18   if not arguments[0]:
19     raise ValueError('Question cannot be empty')
20   size = len(arguments[1])
21   if size < 2 or size > 5:
22     raise ValueError('Incorrect number of options for poll. ' +
23                      'Must be between two and five.')
24
25   poll = Message(parent = instance, sender = player,
26                  msg_type = 'poll', recipient = '')
27   poll.put()
28   arguments.append(poll.key().id())
29   poll.content = simplejson.dumps(arguments)
30   poll.votes = [0] * size
31   poll.open = True
32   poll.voters = ['']
33   poll.put()
34   return get_poll_return_list(poll)
```

3.2.3 The Message Model

Sending messages is the main form of communication among the players in a game instance. Each message is created with a type string, a list of recipients, and a list of contents. New messages can be created directly in server modules or sent from

[3] The empty recipient field means that the message can be fetched by any user that has joined the game instance by selecting the category.

applications with the SendMessage block (see Figure 3-5). Message contents are stored on the server as JSON. When a message is sent back to a client, the JSON is parsed and converted into App Inventor lists. The contents can then be accessed with the list operation blocks shown in Figure 2-5.

Figure 3-5: The method call block for sending a message to other players using the Game Client component.

In the server voting module, polls are represented by messages in the database. The contents field of each poll is a three-item list containing the poll question as the first element, a list of the options as the second element and a numerical identifier for the poll as the third element. The numerical identifier is used by the client to identify polls to the server, but never exposed to the application user. The voting program finds open polls by using a GetMessages call block. Each received poll triggers a GotMessage event with its message type and contents as arguments. These polls are then added to the poll ListPickers for the user to select.

In addition to its default fields, each message can also store dynamic properties that can be assigned to it at runtime. The votes, open, and voters fields on lines 30-32 of Code Listing 3.1 are examples of dynamic properties for a poll. Dynamic properties are stored in the database along with the static properties and can be accessed and modified by other server commands. This flexibility allows for the existing database models to be used for a wide variety of server modules on the same server without modifying the base server code.

3.2.4 Input Validation and Error Handling

Server commands are implemented using transactions. At the beginning of their execution, most server commands perform input validation and permission checking before continuing. In the Make New Poll example, both the question and the options are checked before making any costly database operations. If the arguments provided to the server command are invalid, a ValueError is raised. Raising an unchecked error during a server command results in all actions performed during the request reverting their changes. The failed request will be reported back to the client and trigger the Game Client component's WebServiceError event (shown later in Figure 3-10).

This transactional design makes server command logic simple because application creators can assume an all-or-nothing paradigm for the completion of their server-side actions. Despite this, a network failure could cause a server command to complete successfully on the Game Server but not return its result to the client. For this reason server commands should be created in a way that allows them to be called multiple times without irreversible side effects. In the voting module, the only side effect of a server-side action completing without the user being informed of its success is that he or she will not find out about the change until the next data refresh. However, since the server verifies that all requests are valid before allowing actions to continue, even if a program is acting with incorrect data it will not harm the stored data or affect other users.

3.2.5 Registering Commands

Before a custom server module can be accessed with the Game Client component, the commands must be registered with a request handler. This is done automatically when the application is started by reading in a command dictionary. Shown below is the command dictionary for the demonstration server running at http://appinvgameserver.appspot.com. It enables the server commands for four different applications, which are presented throughout this thesis.

3.2: The command dictionary for four different custom modules. (Excerpt from A.9)

```
custom_command_dict = {
    # Androids to Androids
    'ata_new_game' : ata_commands.new_game_command,
    'ata_submit_card' : ata_commands.submit_card_command,
    'ata_end_turn' : ata_commands.end_turn_command,

    # Bulls and Cows
    'bac_new_game' : bac_commands.new_game_command,
    'bac_guess' : bac_commands.guess_command,

    # Amazon
    'amz_keyword_search' : amazon_commands.keyword_search_command,
    'amz_isbn_search' : amazon_commands.isbn_search_command,

    # Voting
    'vot_cast_vote' : voting_commands.cast_vote_command,
    'vot_get_results' : voting_commands.get_results_command,
    'vot_new_poll' : voting_commands.make_new_poll_command,
    'vot_close_poll' : voting_commands.close_poll_command,
    'vot_delete_poll' : voting_commands.delete_poll_command,
    'vot_get_poll_info' : voting_commands.get_poll_information_command
    ,
    'vot_get_my_polls' : voting_commands.get_my_polls_command
    }
```

This command dictionary enables four different custom modules to operate on the server at the same time. No other code changes are required in order for a custom module to be successfully called from App Inventor.

3.3 Block Logic

After a project's components are selected, code blocks are used to define the behavior of the application. The voting application requires dozens of blocks to control its user interface and properly display polls, but the number required for server communication is relatively low. This section will first look at the block logic used in the poll creation program and then move on to the program used to perform voting.

3.3.1 Poll Creator Blocks

The first action that a user takes after opening the poll creator program is to create or join a poll category. If others have previously created categories, users can join them and add new polls. However, if no categories exist or if users are not satisfied with any of the available choices, they must create a new category.

The category creation process is implemented with the two event handlers shown in Figure 3-6. When users click on the "New Category" button, they are greeted with a text input dialog box that prompts them to enter a new category name. Once they have entered a category name, the AfterTextInput event on the text dialog fires with the category name as its argument. If the user has inputted a non-empty string into the dialog box, a server call is made to make a new game instance with the selected name.

Figure 3-6: Blocks to create new voting categories. When a user clicks on the new category button he or she is shown a text prompt. After inputting a category name, the program will make a server request to create a new public instance with the selected name.

Retrieving and Displaying Polls

After a category has been selected, its polls are retrieved from the server. A category is activated by setting the Game Client component's instance ID to the name of the category. When the Game Client component makes a request, it includes the game ID[4] and instance ID as arguments. Together, the game id and instance ID form a unique key that the server uses to retrieve the game instance from the database and pass it to the voting module's server commands.

Unlike most other components, the properties of the Game Client component can only be modified with call blocks (as opposed to property setters). This emphasizes to program creators that setting a property in a game requires a server request. For example, when the SetInstance function is called, the component makes a request to the server to join the instance. If the server request succeeds, the InstanceIdChanged event triggers with the new instance ID as a parameter.

Figure 3-7 shows the InstanceIdChanged event handler for the poll creator. Once the instance ID has been set, the Get My Polls server command is automatically called.

Managing Polls

The three main actions in the poll creator are triggered with the Delete, Close and Submit buttons arranged horizontally below the poll options. The event handlers for these buttons are shown in Figure 3-8. Each of them invokes a ServerCommand to perform the requested action.

The Close and Delete server commands accept the number of the targeted poll as their only argument. Poll numbers are sent back from the server along with their associated question when a player requests their poll list. The questions and poll numbers are then stored in a global variable which can be accessed by other procedures.

When a user selects a poll question using a ListPicker, the index of the chosen

[4]The game ID is set by the application creator and hard-coded into each application.

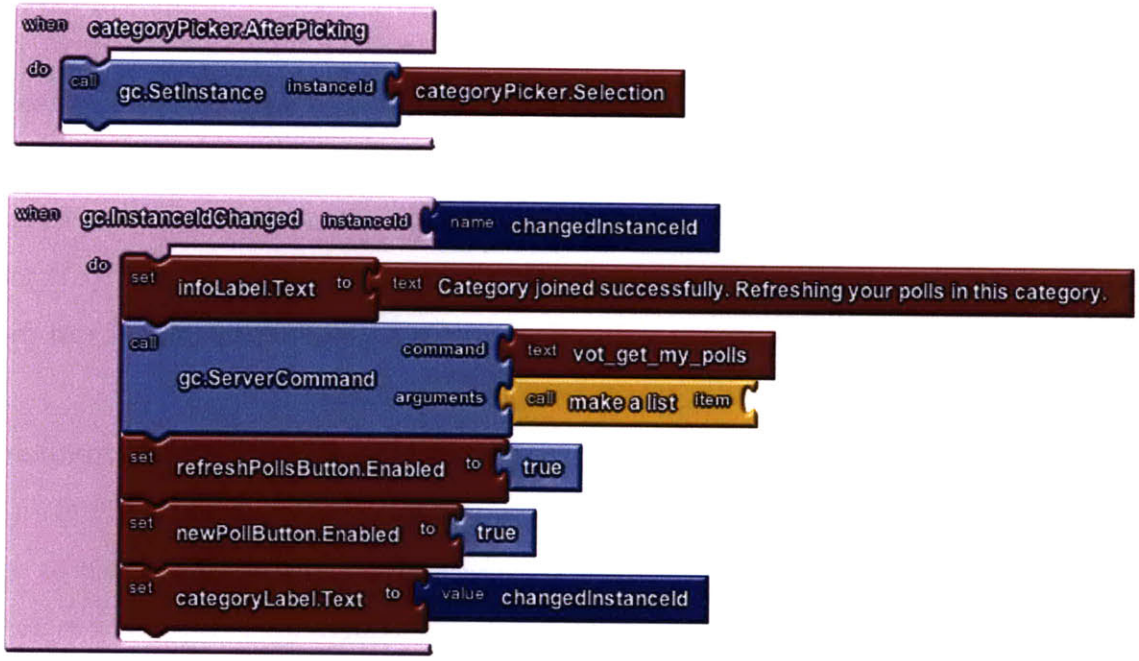


Figure 3-7: Event handlers for retrieving the list of polls owned by the user. After selecting a category, the Game Client component sets its instance ID to the name of the category. When SetInstance completes, it triggers the InstanceIdChanged event handler. Server commands automatically include the current instance ID in their requests. Thus, invoking the Get My Polls server command will only return the polls for the selected category.

question in the ListPicker's elements is used to retrieve the poll's ID number from the global received polls list. This approach is used to create a map from poll question to ID number[5]. Figure 3-9 shows the blocks for selecting a poll in the poll creation program.

Web Service Errors

Given the inconsistency of mobile data connections, it is important that programs deal with connection issues and other problems with calls to web services. To help program creators, the Game Client component triggers WebServiceError events whenever the server aborts a transaction or when a connection failure occurs. Server error messages have all been designed to be human readable and provide

[5]This is done through the use of nested list commands. Once dictionary support is written for App Inventor this particular design method will become much easier and more efficient.

Figure 3-8: Event handlers for the buttons that are used to close, delete, and create polls. Each handler uses variables which are globally accessible to the program as the arguments to its associated server command. The server commands are performed asynchronously and trigger the ServerCommandCompleted event when they finish.

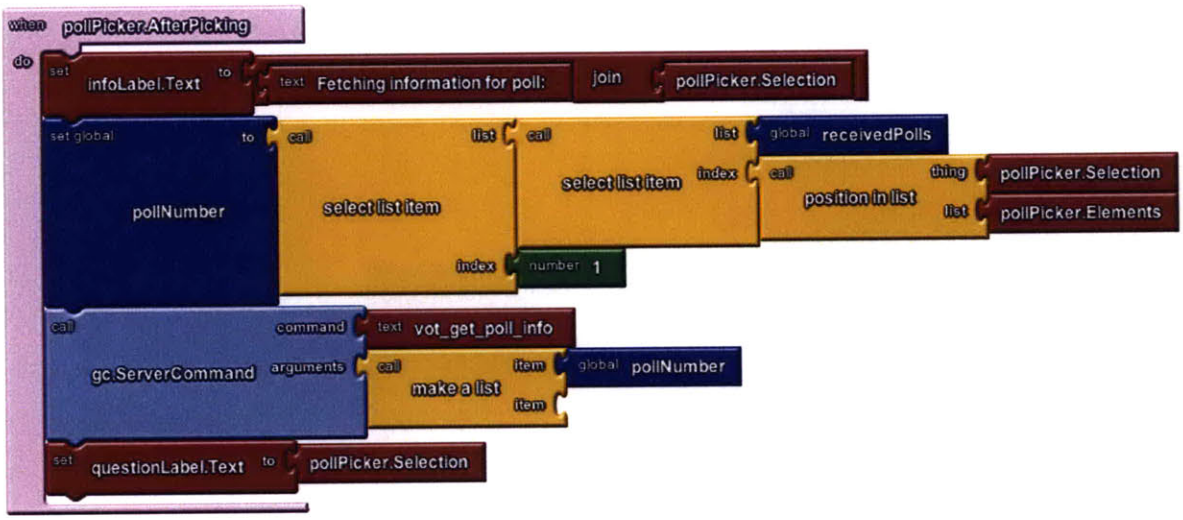


Figure 3-9: An example of using the selection from a ListPicker component to trigger a server command. The global variable receivedPolls has the same ordering as the list of strings that serve as the poll picker's elements. This decouples the information about a poll that is displayed to the user from information kept private by the program.

the user with enough information to determine what has gone wrong. To make dealing with these errors less of a burden, the voting server module was designed to handle repeated inputs of the same command from an out-of-sync client. Thus, as can be seen in Figure 3-10, the only response to a WebServiceError is to inform users that it has occurred. They can then retry their previous action after remedying any problem that arises.

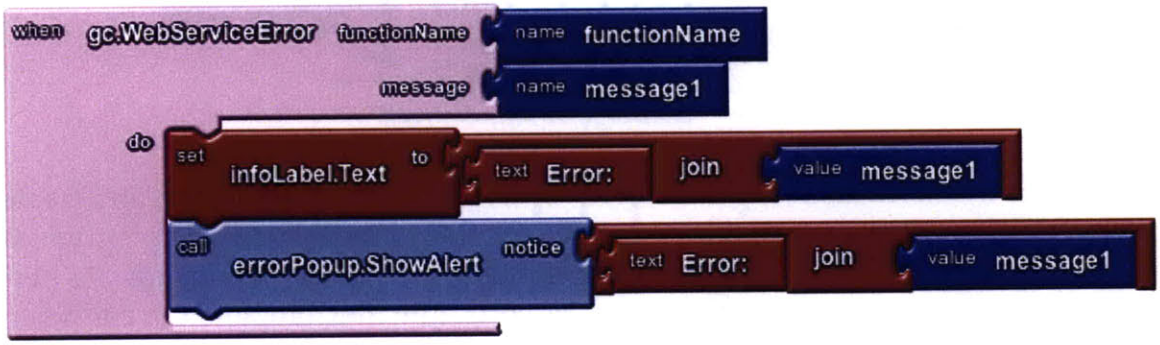


Figure 3-10: Error handling in the voting program. The server module was designed to handle multiple identical responses and to return human readable error messages. This means that simply informing users of errors is sufficient for them to handle the errors on their own.

3.3.2 The Ballot Box

The Mobile Voting Ballot Box is responsible for retrieving polls, casting votes and displaying results. Polls are retrieved automatically when players select a new poll category or when they manually click on the "Refresh Polls" button. The event handler for the refresh polls button is shown in Figure 3-11. Polls are retrieved using the Game Client component's built-in GetMessages call. The message type specified in Figure 3-11 is the empty string. This tells the server not to filter based on message type and instead return all messages that have been sent to the requesting player. The two message types for polls are poll and "closed_poll". All polls are originally created with the message type poll, but are changed to "closed_poll" when the creator of the poll decides to disallow further voting. Because they are handled in different ways, the GotMessage handler checks the message type before processing the poll response.

After the user selects a poll to view, the client requests more information from the server about the status of the poll. If the user has not yet voted, the poll options will be presented and the user will be allowed to submit a vote. Once his or her vote is made, the server sends the current vote totals for each option back to the client application. The ServerCommandSuccess event handler and the procedure to update the user interface with vote counts is shown in Figure 3-12. The event handler checks the type of command that the response is for and invokes the appropriate procedure. If the response was for a Cast Vote command, the client knows that the response contains a message from the server as its first element and a list of the vote counts as the second element. The procedure then selects these items from the response list and updates the user interface.

3.4 Summary

The entire Mobile Voting application includes two Android programs and a custom server module. The Android programs were created using App Inventor. First

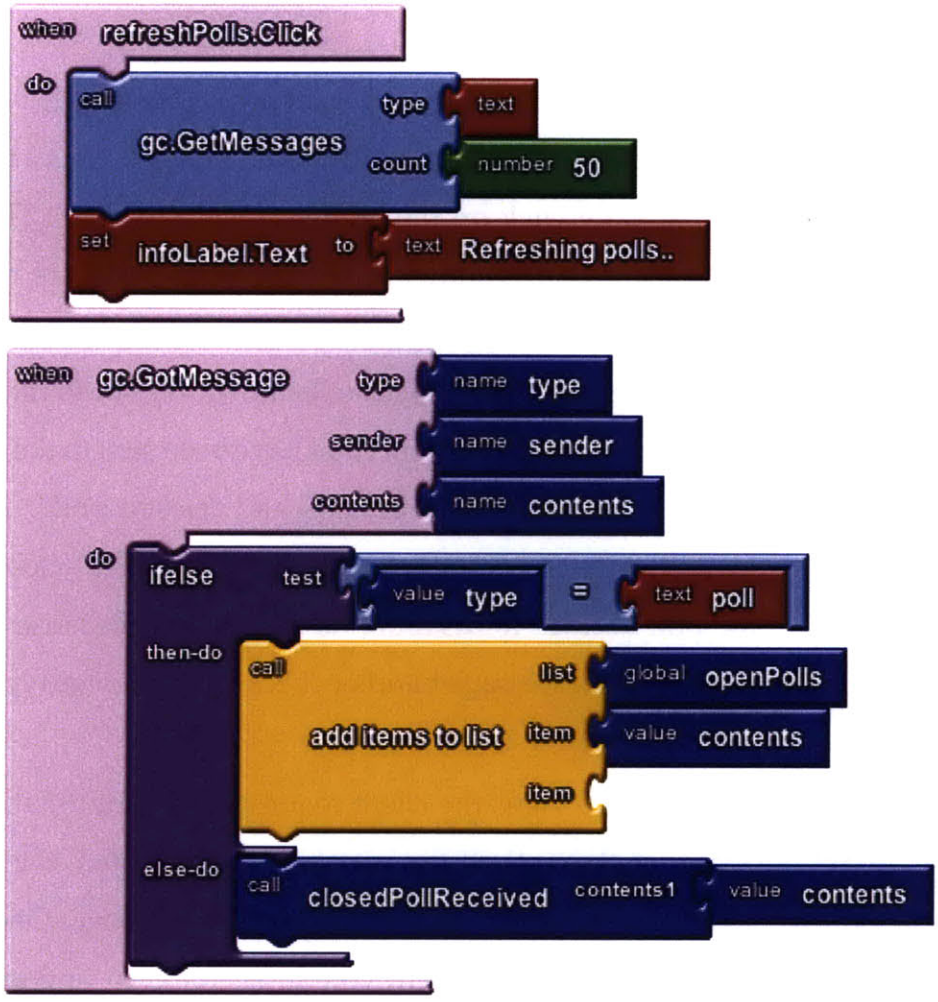


Figure 3-11: The blocks used to retrieve the polls in the voting program. When the GetMessages function returns it parses its response into individual messages and triggers the GotMessage event handler for each one. In this example, new polls are added to a global list that is used to populate a ListPicker component.

the application designer was used to select components and lay out the user interface. Then, the program logic, including calls to the Game Server, were defined with the blocks editor.

In the blocks editor, the Game Client component provides method call blocks that utilize the Game Server API to keep track of polls and execute server commands in the custom voting module.

The voting module built for the Game Server defines seven different custom commands which perform database operations and provide poll information to

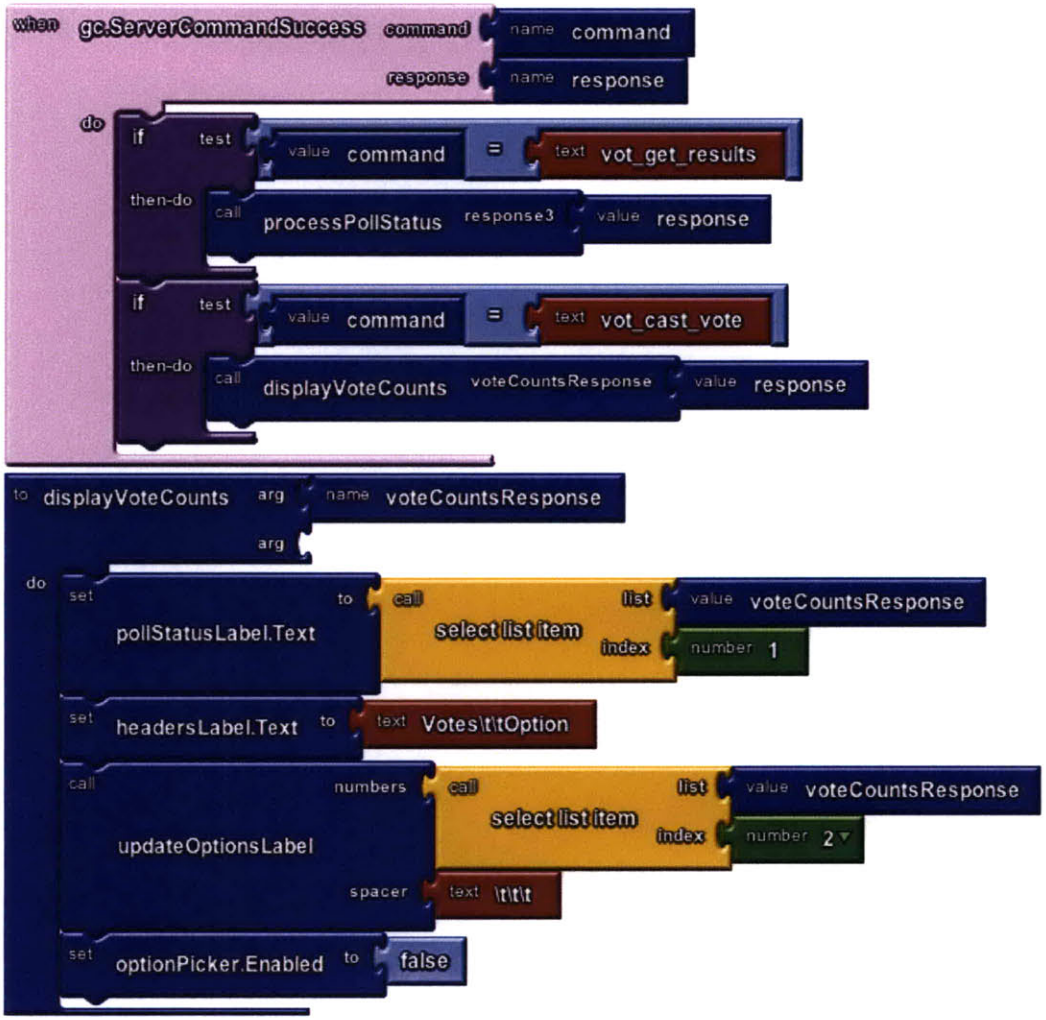


Figure 3-12: The ServerCommandSuccess event handler and the blocks used to update the user interface with the response from a cast vote command. All server commands return App Inventor lists as their response.

the voting application. Each server command accepts a list of arguments and returns a results list which can be interpreted by the Game Client component and used to display poll information.

Now that the application creation process has been explained, Chapter 4 will provide an in-depth look at the details of the server API and the blocks that the Game Client component exposes.

Chapter 4

System Overview

This chapter is an overview of the design decisions and implementation of the Building Blocks for Mobile Games multiplayer framework. It first discusses the Game Server request API, extensions, custom server modules, data models and testing strategy. Then, the Game Client component's properties, method calls and events are presented.

4.1 The Game Server

The Game Server is implemented in Python using the App Engine SDK. The server provides a set of request handlers and server commands which can be called by the Game Client component. Server testing is performed with the NoseGAE plugin for the Nose unit testing system. NoseGAE emulates the App Engine data store on the local file system and runs tests in the restricted App Engine runtime environment[7].

4.1.1 Data Models

The Game Server uses three data models to store game and player information. These data models were presented briefly in Chapter 3.

- Game - Each application has one Game object in the data store. The Game

is identified by the game ID property of the application's Game Client component. The game ID operates as a namespace, allowing each application to maintain its own set of GameInstances.

- GameInstance - A GameInstance represents a group of players participating in a single game. A Game is allowed to be the parent of any number of GameInstance children, but each GameInstance must have a unique instance ID among its siblings. Together, the game ID and instance ID uniquely describe a GameInstance object. GameInstances keep track of their current membership, the list of players who have been invited to them, their current leader, whether they are open to the public, and their maximum allowable player count[1].

- Message - Message objects are used to send information to a player in a GameInstance. Players must explicitly request messages in order to receive them[2]. Thus, creating a message and storing it in the database is functionally equivalent to sending a message with the Game Client component's SendMessages block.

  Messages can be created in custom server commands or using the SendMessage method call block. Messages contain a type, content, time of creation, and the email addresses of their recipient and sender. The content property of a Message object is a JSON string that is decoded into Python types when the Message is accessed by extensions and server commands. Lists, dictionaries, strings, booleans and numbers are all acceptable content types for the contents of a message. When the Game Client component receives a message it automatically converts the content into YailLists[3] to return to the GotMes-

[1]This is an optional field. All GameInstances are initially created with no maximum player count. It can later be set with a server command by the game creator. Setting the maximum number of players in an instance causes it to become full if the number of players that have joined it reaches the maximum. An instance that is full will both disallow further players from joining and keep it from appearing in the invited games list of all players.

[2]This is similar to the setup used by POP email.

[3]Dictionaries are converted into a list of lists of two items. Each sublist represents one entry in the dictionary and has the key of the entry as its first item and the value of the entry as its second

sage event.

GameInstances and Messages allow dynamic properties to be added to them at runtime[4]. Dynamic properties are automatically created when database models are placed in the database. An example of the assignment of dynamic properties to a Message object is shown below in the Make New Poll command of the custom voting module. Each field is stored in the App Engine database when the poll is committed to the database by calling its "put" method. Later, when the Message is retrieved from the database, all of its dynamic properties can be accessed and modified.

4.1: Adding dynamic properties to a Message object. (Excerpt from A.13)

```
1    poll = Message(parent = instance, sender = player,
2                   msg_type = 'poll', recipient = '')
3    poll.votes = [0] * size
4    poll.open = True
5    poll.voters = ['']
6    poll.put()
```

Using dynamic properties allows custom server modules and extensions to add functionality to GameInstance and Message objects without modifying the request handlers or other server code. Messages that are retrieved using the GetMessages command from the Game Client component are returned without any dynamic properties in order to standardize the format of returned messages.

4.1.2 Request API

The server defines nine request handlers which can be called by the Game Client component[5]. Each request handler follows the same execution pattern:

1. The request handler retrieves the POST variables from the Game Client's request. Every request handler accepts a game ID, instance ID, and player

item. This conversion will change once support for dictionaries is added to App Inventor.

[4]This design is called an Expando model.

[5]The code that implements the request handlers can be found in Code Listing A.1.

ID. The player ID must include the email address of the requesting player[6]. Most requests also require additional variables in order to properly execute. For instance, the SendMessages request handler requires the message type, contents and recipients list to be included in the POST variables.

2. The server starts a transaction and executes the request with the retrieved parameters. If an uncaught error is encountered during execution, the transaction will revert its changes and return an error message to the Game Client.

3. The transaction returns the database model specified by the game ID and instance ID of the request along with the result of the request.

4. An OperationResponse object is created with the result of the transaction[7]. The current state of the targeted instance is also included with the OperationResponse in order to keep the Game Client up to date on changes to the leadership and membership of the instance.

5. The OperationResponse is converted to JSON and returned to the requester.

The Game Client component then processes the information in the OperationResponse and triggers appropriate events.

The nine request handlers and the values they return to the Game Client component are as follows:

- GetInstanceLists returns three lists of instance IDs:
  - Public - Instances that do not require invitations to join.
  - Joined - Instances that the player has previously joined or created.
  - Invited - Instances that the player was invited to but has not yet joined.

[6]To make it easier to supply email addresses, the Game Server will automatically use a regular expression to parse the email address from a player ID. This means that email addresses formatted with a display name (e.g. "Bill Magnuson" ⟨billmag@mit.edu⟩) can be submitted without issue.

[7]The result of a Game Server transaction is always formatted as a Python dictionary. This dictionary is converted into a JSON object and passed back to the Game Client component in the OperationResponse. If the result contains information such as retrieved messages that must be passed to event handlers, the Game Client component will extract the information from the JSON object and convert it into App Inventor data types.

The Public and Invited lists only include instances that currently have fewer players than the maximum number allowed to join that instance. Thus, any instance in these lists can be joined by the requesting player at the time of the request.

- NewInstance - Creates a new instance of the game specified by the game ID argument. The instance ID parameter is used as the first candidate for the ID of the new GameInstance object. However, if the requested ID is already assigned to a GameInstance, NewInstance will append a number on the end of the candidate instance ID to make it unique. Finally, the instance ID of the created GameInstance is returned to the Game Client so that it can use it as a POST variable in future requests.

- InvitePlayer - Invites a new player to an instance. Once a player is invited to an instance, the instance ID will appear in his or her Invited instance list until the game reaches its maximum membership. Non-public games can only be joined by players who have been previously invited to them. When players are invited to a public game, the game's instance ID will appear in both their Public and Invited lists.

- JoinInstance - Attempts to add the requesting player to the specified instance. If the player is already in the instance, the request returns the instance ID parameter in the OperationResponse. If he or she is not in the instance, but is allowed to join because the instance is public or the player has been invited, the player is added to the requested instance and the instance ID of the joined instance is returned.

  If a player attempts to join an instance that he or she is not allowed to join, an error is raised and the request is aborted. The Game Client component will then trigger a WebServiceError event with an error message describing the reason that the player was unable to join the requested instance.

- LeaveInstance - Removes the requesting player from an instance. If the re-

questing player is the leader of the instance, leadership is transferred to the player that has been in the game the longest. If the player is the last member of the instance, no new leader can be assigned and thus the instance is closed so that no one may join it in the future.

- GetMessages - Runs a database operation to find Message objects sent to the requesting player that match the search parameters provided by the Game Client:
  - Type - The string used as the type when the Message was created. If the specified type is the empty string, Messages of any type are returned.
  - Count - The maximum number of Messages to return at once.
  - Time - All messages returned must have been made after this time. The Game Client component automatically tracks the time stamp of the most recently received Message for each message type. When it makes a GetMessages request, it includes this time stamp in order to ensure that every Message returned by GetMessages has not been previously received.

- NewMessage - Sends a new message to a list of recipients. This request allows the requester to define the type, content and recipients of the message. The content can be any JSON string[8]. If multiple recipients are provided, a message is created for each of them. A player may also choose to send an empty recipients list. With empty recipients, the message is considered public and can be requested by any player in the instance.

- SetLeader - Sets the leader of a GameInstance to a new player. If a player makes this request while they are not the leader, no change is made and the request will provide a return value that indicates the lead change failed. If the requesting player is the leader, then the request succeeds and the email

[8]The Game Client component automatically converts App Inventor lists into JSON when messages are created.

address of the new leader is returned to confirm that the new assignment was successful.

When a new instance is created by a player, he or she automatically becomes the leader of the game. The current leader is included in every OperationResponse to the Game Client component so that the game learns of leader changes as soon as possible.

The significance of a leader is determined by the game designer. Some programs, such as Mobile Voting, do not use the leader of their instances and never change them. Other games, such as a card game with a dealer, may pass leadership every turn or at other transition points.

- ServerCommand - Server commands are a class of operations that are narrowly useful for application creators. A server command request must include a command key and a list of arguments to pass to the server command.

  Generic handling of server commands allows App Inventor programs to execute user defined procedures on the server without making changes to the Game Client component. This is an important feature because users of App Inventor are not able to make changes to the Game Client component in order to support requests that are specific to games they are creating.

  Server commands are used to invoke both built-in server commands and commands defined in custom server modules. Built-in server commands include a set of server commands that can modify properties of GameInstances and extensions. Custom modules are groups of commands that have been built for a specific purpose. An example of a custom server module is seen in Chapter 3 for the Mobile Voting application. Extensions and custom modules are each explained in more detail below.

In addition to their stated return values, NewInstance, JoinInstance, and LeaveInstance return the same instance lists returned by the GetInstanceLists request. This allows the Game Client component to keep its instance lists up-to-date without making explicit calls to GetInstanceLists.

4.1.3 Extensions

Extensions are collections of server commands that provide generic functionality for use by custom server modules. The commands in a server module can be accessed from App Inventor programs by making ServerCommand requests or be directly called by custom modules. Two example extensions are provided in the default Game Server:

- Scoreboard - Stores a score for each player in an instance. Players can modify and retrieve individual scores using server commands. If a player requests the entire scoreboard, it is formatted into a nested list that can be easily formatted for display with a ListPicker component before being returned.

- Card Game - Deals cards and keeps track of players' hands for an instance. The deck used can be set to any list of items meant to represent cards, however, the default is the standard 52 card Anglo-American deck. The Card Game extension implements server commands to deal cards to all players, draw cards from the deck, pass cards to another player, discard cards from a player's hand and shuffle the deck. Each time a change is made to a player's hand, Card Game automatically sends that player's new hand to him or her as a Message. This allows a player to receive the current state of his or her hand by making a GetMessages request.

These extensions are used in the MoBulls and Cows and Androids to Androids games shown in Chapter 5.

4.1.4 Custom Modules

Custom modules are collections of server commands, which are created to provide advanced functionality to App Inventor programs. Custom server commands can implement their own game logic, utilize third-party Python libraries, call extensions directly and access database models.

Implementing operations in custom server modules is an important mechanism for moving application functionality from the Android client program to the Game Server. Custom server modules allow application creators to implement commands to achieve any of the following outcomes:

- Simplifying game logic by grouping operations into a single server command. Custom server commands are executed using the ServerCommand request handler, which means that they are completed inside of a transaction.

- Shifting computationally-intensive operations to the server. One example use case is creating a chess game with a computer player. Performing computations for a high-quality computer controlled chess player requires a large amount of computation which would hog the resources of a mobile phone, but could be easily computed on an external server.

- Invoking third-party libraries to access external data sources, utilize web APIs or read RSS feeds. An example of a program utilizing a third-party data source is seen in the Amazon example in Chapter 5.

- Modifying database models to store more information relevant to the game being created. The Mobile Voting application presented in Chapter 3 uses this technique to store special poll properties in Message objects.

- Helping students in assignments or class projects by having a member of the course staff implement server commands for students to use. For example, in a lesson about using third-party data providers, a teacher could build a server module that accessed eBay auction listings based on keywords. Students could then be challenged to build applications that used the auction listings in an interesting way, but not have to waste time learning the technical details of connecting a mobile phone to eBay's services.

Each custom server command accepts the same three parameters: a database model, the email address of the requesting player, and a list of arguments. The

database model and email address of the requesting player are automatically provided by the ServerCommand request handler from the game ID, instance ID and player ID POST variables. The *arguments* parameter is a variable-length list of parameters to pass to the function that implements the server command. The expected order and makeup of the *arguments* parameter varies across server commands.

The identical, three-item method signature is required for server commands so that the ServerCommand request handler can successfully execute the commands without knowing the expected format of the arguments list.

Custom modules are enabled on a Game Server by registering their available commands in the ServerCommand dictionary. Registration is done automatically when the server starts if the server commands are added to a special custom command dictionary located in the Custom Modules folder of the Game Server. The custom command dictionary for the default Game Server is shown in Code Listing A.9.

4.1.5 Game Server Testing

Game Server testing is done using the Nose unit testing system[6]. Nose works by identifying test functions and executing them one at a time. Nose also provides two plugins that implement functionality to test Google App Engine servers:

- WebTest - WebTest starts the Game Server and emulates the functioning of the request handlers by accepting POST and GET commands, executing the requested transactions and returning OperationResponse objects. Test cases can then inspect the returned OperationResponse objects.

- NoseGAE - NoseGAE runs test cases in the limited App Engine runtime using a mock database on the local machine[9]. Combined with WebTest, NoseGAE allows unit tests to simulate POST requests as they would come

[9]The mock database is stored in a temporary file on the local hard disk and implements the same semantics and operations as the App Engine database.

from the Game Client and later inspect the state of the database to confirm that the correct changes have been made.

4.2 The Game Client Component

Components are the primary functional abstraction in App Inventor. Just as Java coders include libraries in source files to gain access to the library functionality, App Inventor users add components to their projects in order to gain access to new block drawers.

Components are implemented in Java and utilize libraries from both Sun's JDK and the Android SDK to perform actions during the execution of an application. Blocks are automatically created for each component by scanning its source file's public functions for Java annotations which label each function as a property, event handler or method call.

The Game Client component is implemented to interface with the Game Server. The code for the Game Client component and its utility classes is available in Appendix B.

4.2.1 Properties

The Game Client component provides access to nine properties:

- GameId - The ID for this game. The game ID can only be set in the application designer. This emphasizes to game creators that each Game Client component should target a single Game object and that the game ID should be a permanent property of the program.

- InstanceId - The ID of the current instance that the player is participating in. Whenever a player joins, leaves or creates a new instance, this value changes. No setter is available for the instance ID. Instead, the SetInstance method call block must be used because changing the instance ID requires successful

completion of the JoinInstance server request and cannot simply be changed in the client.

- InvitedInstances, JoinedInstances and PublicInstances - Each of these provide the most recently received lists for the requested instance type. LeaveInstance, SetInstance, GetInstanceLists, and MakeNewInstance requests update all three instance lists when they return successfully.

- Leader - The most recently received leader for the current instance. Every successful server request includes the current leader in the OperationResponse. This means that the Leader property can change locally as a side effect of making any request.

- Players - The list of players that have joined the current instance and not yet left. Note that players do not need to have a game actively open to appear in this list, they only need to have once joined the game. The Players list is also sent with every OperationResponse and evaluated for changes so that changes to the game membership can be disseminated quickly to all players without forcing them to make special requests.

- ServerUrl - The web address of the Game Server. Like the game ID, this can only be set in the component properties panel in the application designer. This is to disallow an application from accidentally changing the server URL partway through a game.

- UserEmailAddress - Provides the Google account address that was initially used to register the phone. This is the only property with a setter block, although it should only be used in testing situations[10]. If the setter is used, the UserEmailAddress should be set when a program first opens because the Game Client component has not been designed to handle changes to the UserEmailAddress during program operation. Additionally, allowing play-

[10]This could be necessary if an emulator fails to retrieve a registered email address or an application creator needs to use the same device to simulate multiple players.

ers to set their own email address could result in players spoofing their identity and interfering with games.

4.2.2 Method Calls

The Game Client component defines one method call block for each request handler in the server API presented in Section 4.1.2. Each method call block calls a function in the Game Client component. This starts an asynchronous operation that completes the server request in a separate thread and triggers events after it returns. Performing the request in a separate thread allows the program to remain responsive while server requests are completing.

Each server request automatically includes the GameId, InstanceId and UserEmailAddress properties in the POST variables. If a server request handler requires additional parameters, the method call blocks for those requests will include sockets for each of the remaining parameters. These parameters are defined by the application creator by plugging values into the argument sockets. The blocks compiler performs checks at packaging time to ensure that all argument sockets have been filled with the appropriate block type. This helps keep new users from making mistakes when using method call blocks.

When a server request returns, it automatically decodes the OperationResponse JSON object and checks the instance ID, leader, and players fields. If the instance ID does not match the current ID and the operation is not expected to result in a change of the instance ID, the response is ignored. This is done to eliminate slow and out-of-order server requests that return after the user has joined a new instance. If the leader changes, the Leader property is updated and a LeaderChanged event is triggered. Similarly, the players list is compared to the current Players property and if the received list is different, the Players property is updated and the appropriate PlayerLeft and PlayerJoined events will trigger.

After the OperationResponse has been checked, the transaction response in the OperationResponse is extracted and returned to the function's asynchronous

callback. When a GetMessages or ServerCommand call returns, it retrieves the response contents and triggers either GotMessage or ServerCommandReturned events. If a GetMessages request returns multiple messages, the GotMessage event handler will fire once for each message.

When a request is completed, it triggers a FunctionCompleted event with its function name as the only argument. This allows program creators to perform actions when calls such as GetMessages complete successfully to implement a message reading loop as seen in the Bulletin Board example in Section 5.1.

4.2.3 Events

Events are triggered automatically by the Game Client component when special conditions are satisfied. Many of these events have already been mentioned above in the context of property changes or returning method calls. The events that cause each of the 14 Game Client event handlers are as follows:

- FunctionCompleted - A function completed successfully. This is called with the name of the function as the only argument.
- GotMessage - A message was received after a call to GetMessages. Each received message includes its type, sender and contents.
- Initialize - Triggered automatically at program startup. This should not be used in the Game Client except to set the UserEmailAddress when testing or debugging.
- InstanceIdChanged - A call to SetInstance, MakeNewInstance, or LeaveInstance completed successfully and the InstanceId property changed as a result. The new value of the InstanceId property is provided as an argument.
- Invited - A request that updated the instance lists completed successfully and the player has been invited to a new instance. The ID of the instance the player was invited to is passed to the event handler.

- NewLeader - The leader of the current instance has changed. This could be s the result of a player (including the current one) calling SetLeader or a ServerCommand changing the leader field of the current GameInstance object.

- NewInstanceMade - A MakeNewInstance request completed successfully. Like InstanceIdChanged, the event handler provides the current value of the InstanceId property as its only argument.

- PlayerJoined and Player Left - The Players property has changed due to a player entering or leaving the instance. His or her email address is provided as an argument to the appropriate event handler. These handlers can trigger multiple times on a single request if more than one player enters or leaves a game.

- ServerCommandFailure - A ServerCommand failed. The event handler provides the command key and the original arguments to the ServerCommand.

- ServerCommandSuccess - A ServerCommand succeeded. The Game Client passes the command key and the ServerCommand response as arguments to the event. The command key is provided so that the program knows how to handle the response correctly.

- UserEmailAddressSet - The user email address property has been successfully set to a non-empty value. This event should be used to initialize any web service functions. The UserEmailAddress will attempt to set itself to the Google account registered with the phone. If this fails, the UserEmailAddress must be set with the property setter.

- Errors - The Game Client component triggers two different error events:

  - Info - Triggered when a player attempts to perform an action with improper arguments.

  - Web Service Error - Caused by a network failure or server error. These errors are raised with the name of the method call that caused the error

and a text value containing an error message. If the WebServiceError occurs because of an aborted server request, the message will be the text of the server exception. Otherwise, the message is a summary of the network failure that occurred.

4.3 Summary

Together, the Game Client and Game Server enable a wide variety of applications and games to be built. The next chapter presents four example applications to demonstrate the many different uses of the Building Blocks for Mobile Games multiplayer framework.

Chapter 5

Further Examples

This chapter presents four example programs that make use of the Building Blocks for Mobile Games multiplayer framework in different ways. The first, Bulletin Board, is implemented using the unmodified Game Server and requires no use of server commands. It functions as a multiuser online message board. Users can create or join different boards and leave messages for others to see.

The second application is a reimplementation of a program made for a class being taught at the University of San Francisco[1]. With a custom server module, it accesses Amazon's E-Commerce Services to look up books by keyword or ISBN. With Building Blocks for Mobile Games, the entire program can be made with under 50 blocks and a 25-line server module. This program shows the potential for games to utilize online data providers and other web services.

The next application, MoBulls and Cows, is a Bulls and Cows[2] game variant which depends on the Game Server to perform game logic and keep score. MoBulls and Cows uses the Scoreboard extension to keep track of the high and average scores of all players so that users can compete against each other.

The final application is a multiplayer card game called Androids to Androids

[1]The class, CS 107/103 - "Computing, Robots, and the Web" is being offered during the 2010 spring semester and is taught by Professor David Wolber. Professor Wolber also participated in the original App Inventor pilot program in fall 2009.

[2]Bulls and Cows is a game similar to the popular game Mastermind. Full rules and a description of the game can be found at http://en.wikipedia.org/wiki/Bulls_and_cows.

that uses a custom server module, and both the Card Game and Scoreboard server extensions. The game uses a state machine that permits a player to close the program in the middle of a game and return to it later without losing his or her place. This also allows players to simultaneously participate in multiple instances of Androids to Androids with different groups of players.

Together, these examples illustrate the range of use case cases from using an unmodified server, to accessing web services with third party libraries to leveraging server extensions and even modifying database models to fit specific needs.

5.1 Bulletin Board

The Bulletin Board application uses game instances as separate bulletin boards that contain messages posted by users. Figure 5-1 shows the interface for viewing the FreeFood bulletin board. Users select the board they would like to view from a ListPicker that includes all public bulletin boards. After joining, the player can see the last 10 messages posted to the bulletin board and is able to post his or her own messages for others to see. Every operation required to build Bulletin Board is included in the default Game Server. The Bulletin Board design can also be reused by other programs to easily add real time chat capabilities.

When a user opens Bulletin Board, a GetInstanceLists request is made in order to populate the list of currently available bulletin boards. While this is happening, the "Pick Board" button is disabled. Once GetInstanceLists returns, the user is informed that the list of bulletin boards has been refreshed and the button becomes enabled. At any time after this, the user may select a new bulletin board to view and replace the currently displayed messages.

To fetch new messages automatically, Bulletin Board uses a Clock component which triggers a Timer event every 10 seconds. The handler for the Timer event retrieves new messages from the server. The event handler is shown in Figure 5-2. The body of the event handler uses a boolean value to make sure that a second GetMessages call is not made before the first one completes. This is done by setting

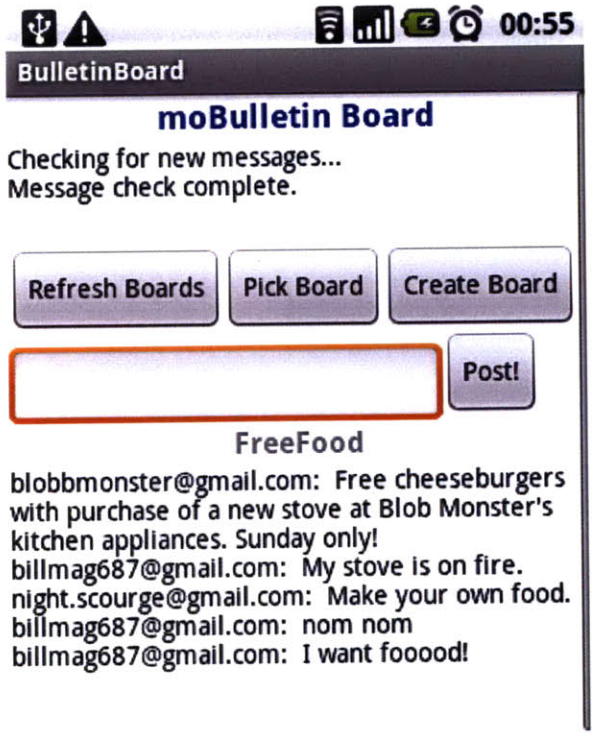


Figure 5-1: Viewing the FreeFood bulletin board.

the variable to false when starting the request and only returning it to a value of true when GetMessages returns.

When a new message is received, its sender and contents are formatted into a display string and added to the top of the list of posted messages. The message-reading loop and GotMessage handler (shown in Figure 5-3) rely on the assumption that the Game Client component will only request new messages when a call to GetMessages is made.

5.2 MoBulls and Cows

MoBulls and Cows is a version of the classic pen and paper game Bulls and Cows, which uses a custom server module with two commands. Each time a player opens MoBulls and Cows, a new game is started by making a server request. At the beginning of a new game, the server randomly chooses a sequence of four colors from a set of six. Each selected colors appears only once in the solution. This

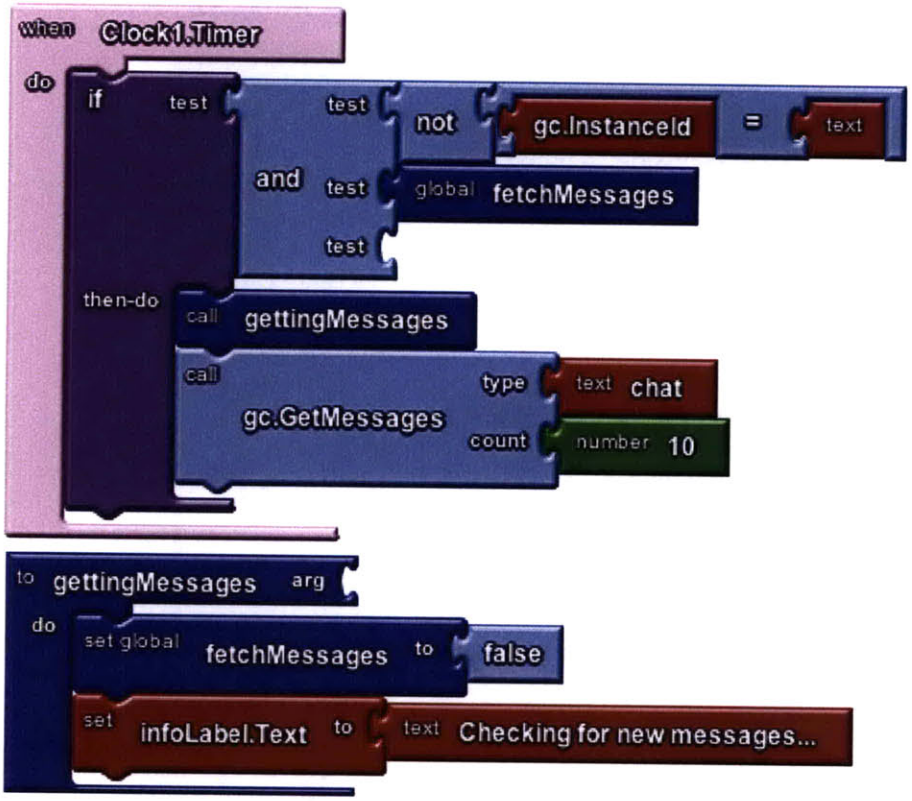


Figure 5-2: The Bulletin Board message reading loop. Bulletin Board uses a Clock component to make message requests every 10 seconds.

solution sequence is only known by the server.

The player then attempts to guess on the correct sequence. After each attempt, they are informed of how many "bulls" and "cows" are in their guess. A "bull" represents a correctly guessed color in the correct position and a "cow" indicates that a color in the guess is correct, but it is in the wrong position.

The player begins with a starting score of 96^3. After each guess is made, two points are deducted for each item in the guess that has a color not appearing in the solution and one point is deducted for a correct color that is in the wrong spot (a cow). No points are deducted for a bull. If a player does not determine the correct sequence before they run out of guesses, they lose the game and must start over.

To submit a guess, a player chooses a color for each of the four places in the

[3]This starting score is chosen so that a guess with zero "bulls" and "cows" on every turn would result in a score of zero.

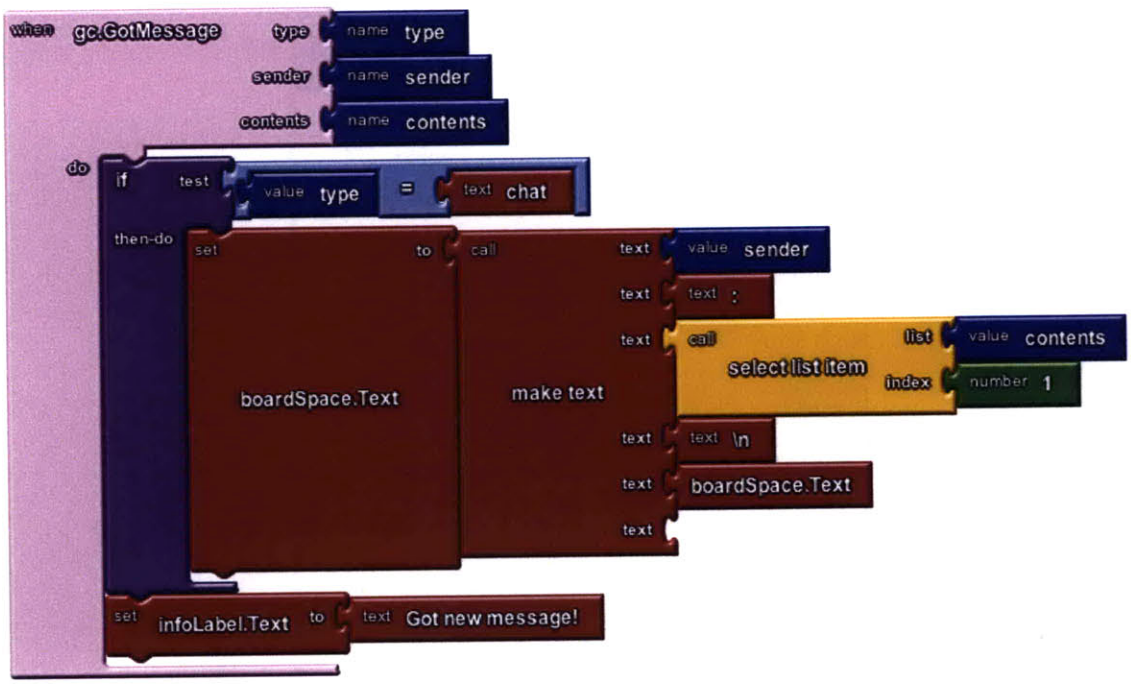


Figure 5-3: The event handler for new messages. When a new message is received, its sender and content are merged into a single text value and added to the bulletin board display.

solution. MoBulls and Cows uses ListPicker components that change their background colors depending on the colors chosen to display the current guess. These can be seen to the left of the "Submit Guess" button in Figure 5-4. When a player hits Submit, the game checks to make sure that the player is not accidentally repeating a guess and then sends it to the server. The Click handler for the "Submit Guess" button is shown in Figure 5-5

The Bulls and Cows custom server module then processes the guess, determines the number of "bulls" and "cows", and adjusts the player's score accordingly. If players guess the correct solution, they are awarded their final score and the current game scoreboard is sent back with the server response.

In order to provide a game-wide scoreboard that incorporates all users of the program, the same game instance is used for all players. At any time, players can view the scoreboard by clicking on the "View High Scores" ListPicker. This will show a screen like the one shown in Figure 5-6 with the high and average scores

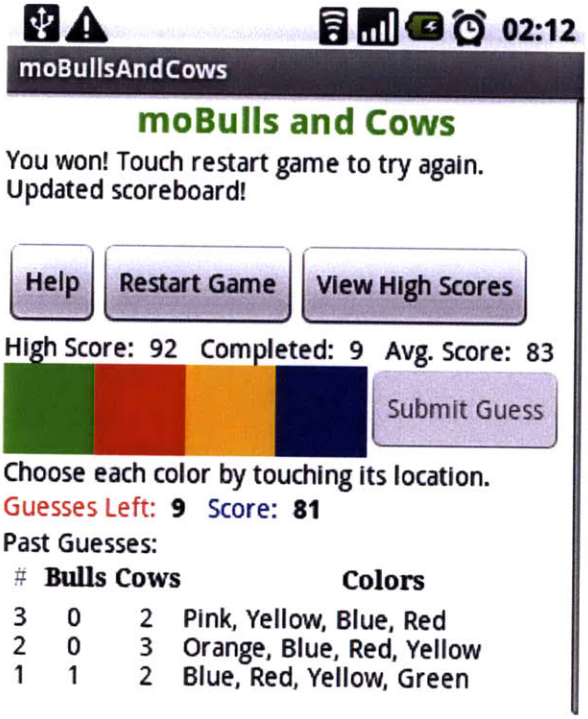


Figure 5-4: The MoBulls and Cows game after submitting the correct sequence. Each guess is sent to the server when the player hits the "Submit Guess" button. The server then checks the guess against the correct sequence and returns the number of "bulls" and "cows". If the player wins, the server will update his or her score statistics and send them back with their final score.

of all players in the game.

If a server command fails due to network problems, MoBulls and Cows will notify the user of the failed attempt and automatically retry up to a maximum of five times. With this approach, it is important to guard against scorekeeping issues that could arise from the client automatically submitting the same guess more than once. To avoid this problem, the Submit Guess function caches the most recent guess and returned value. If the client submits the same guess repeatedly, the custom module does not modify the database and instead replies with the cached return value. This caching scheme requires only six extra lines of Python code in the server module[4]

[4]Four of the six lines are shown in Code List 5.1. Two more are required in the New Game command to initialize the dynamic properties to empty values.

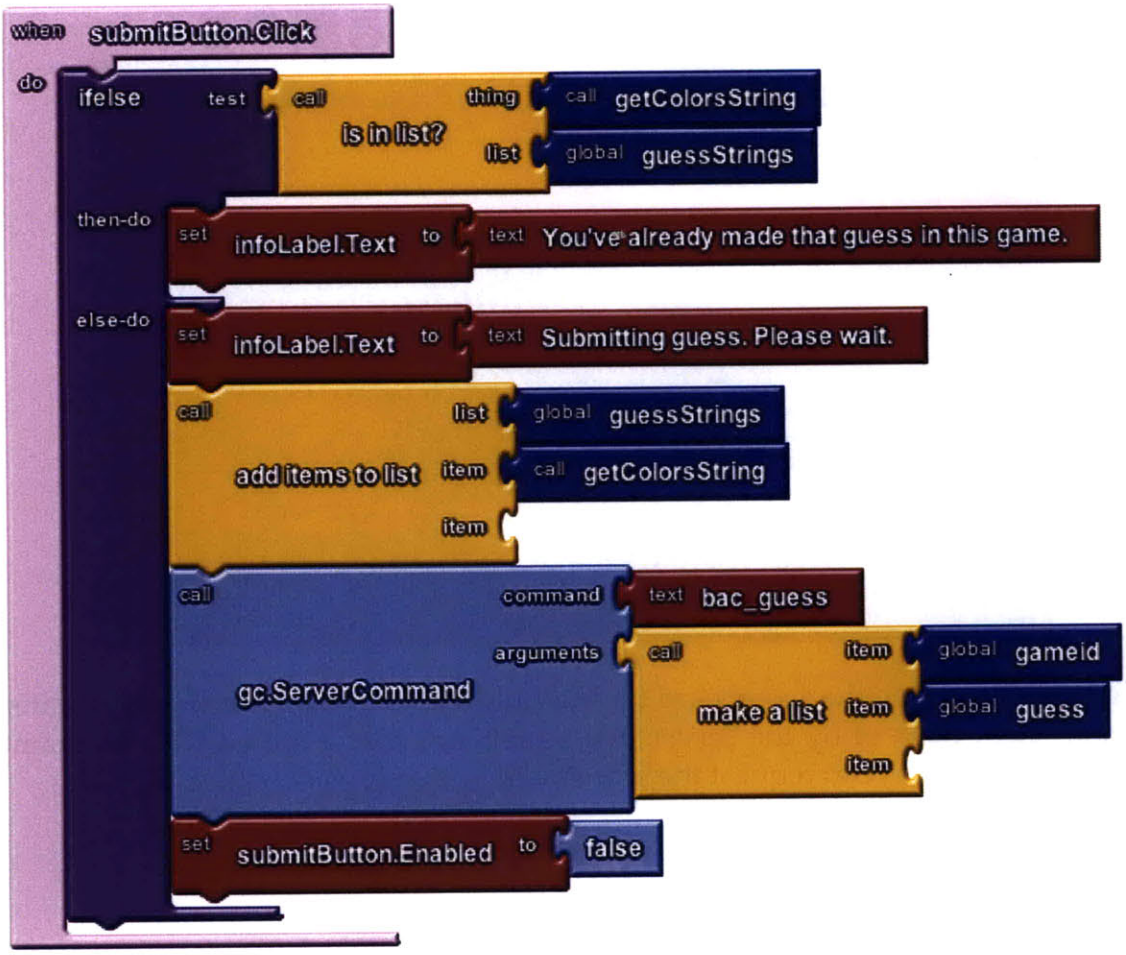


Figure 5-5: The blocks used to submit a new guess to the Game Server. The game first checks to make sure that the player has not previously tried the same guess and then submits it to the server.

5.1: The MoBulls and Cows server command to submit a new guess. Input validation and game ending code has been omitted for brevity. At the end of the method, the last guess and reply are saved as dynamic properties of the Message object that stores the MoBulls and Cows game information. If a subsequent guess has the exact same arguments, the computation and score deduction are skipped. Instead, the saved reply is immediately returned. (Excerpt from A.12)

```
1
2
3 def guess_command(instance, player, arguments):
4   guess = arguments[1]
5   game = db.get(Key.from_path('Message', int(arguments[0]),
6                               parent = instance.key()))
7
8   # Check to see if the received guess is identical to the last
```

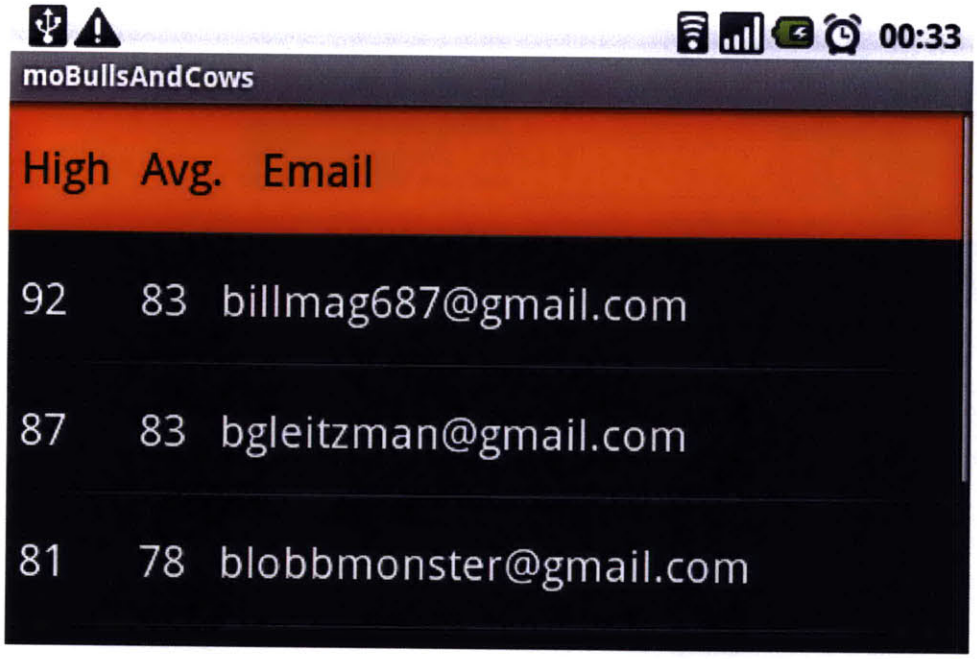


Figure 5-6: Viewing the scoreboard for MoBulls and Cows. High scores and statistics are kept track of by the server in a scoreboard that is stored with the game instance. Programs can request the scoreboard with a server command.

```
9     # one received. If so, return the saved reply.
10    if guess == game.bac_last_guess:
11      return simplejson.loads(game.bac_last_reply)
12
13    return_content = None
14
15    if guess == game.bac_solution:
16      # The player has won.
17      # Code omitted for brevity.
18    else:
19      game.bac_guesses_remaining -= 1
20      bulls = cows = 0
21      for i in xrange(solution_size):
22        if guess[i] == game.bac_solution[i]:
23          bulls += 1
24        elif guess[i] in game.bac_solution:
25          cows += 1
26
27      score_deduction = solution_size * 2 - cows - 2 * bulls
28      game.bac_score -= score_deduction
29      return_content = [game.bac_guesses_remaining, game.bac_score,
30                        bulls, cows]
31
32    # Save the guess and reply with the Message object.
33    game.bac_last_reply = simplejson.dumps(return_content)
34    game.bac_last_guess = guess
35    game.put()
```

```
36    return return_content
```

5.3 Amazon

Amazon is a simple program for looking up books in Amazon's listings. It demonstrates a mobile application created with a few dozen blocks and a short server module that accesses external online resources.

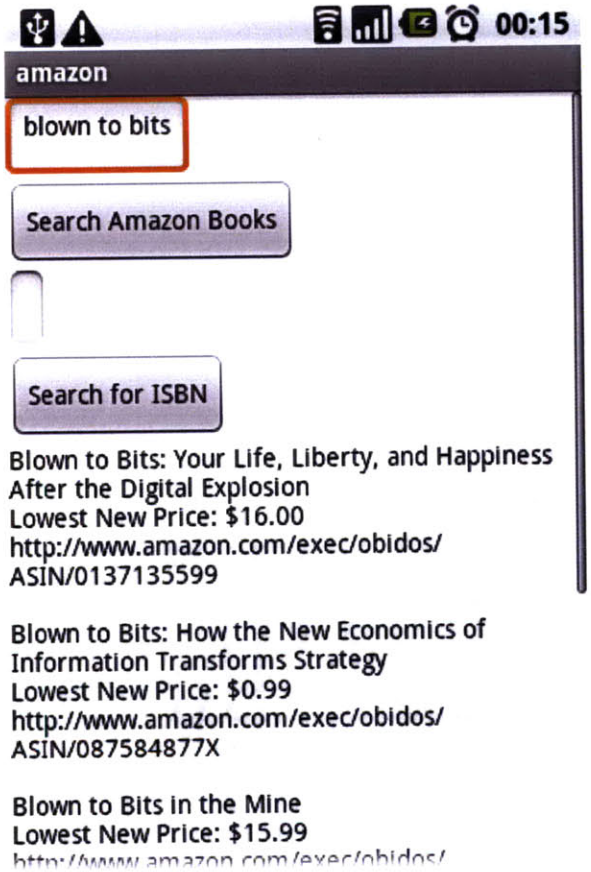


Figure 5-7: The Amazon program after looking up a book by keyword. The Game Server accesses the Amazon E-Commerce Services to perform a query for the keyword and returns any books it finds to the program.

Users operate the Amazon program by entering a book keyword or an ISBN into a text input box and clicking the search button. Then, a server command is made, which uses a custom server module that accesses the Amazon E-Commerce Services API to perform a search of Amazon.com's book inventory.

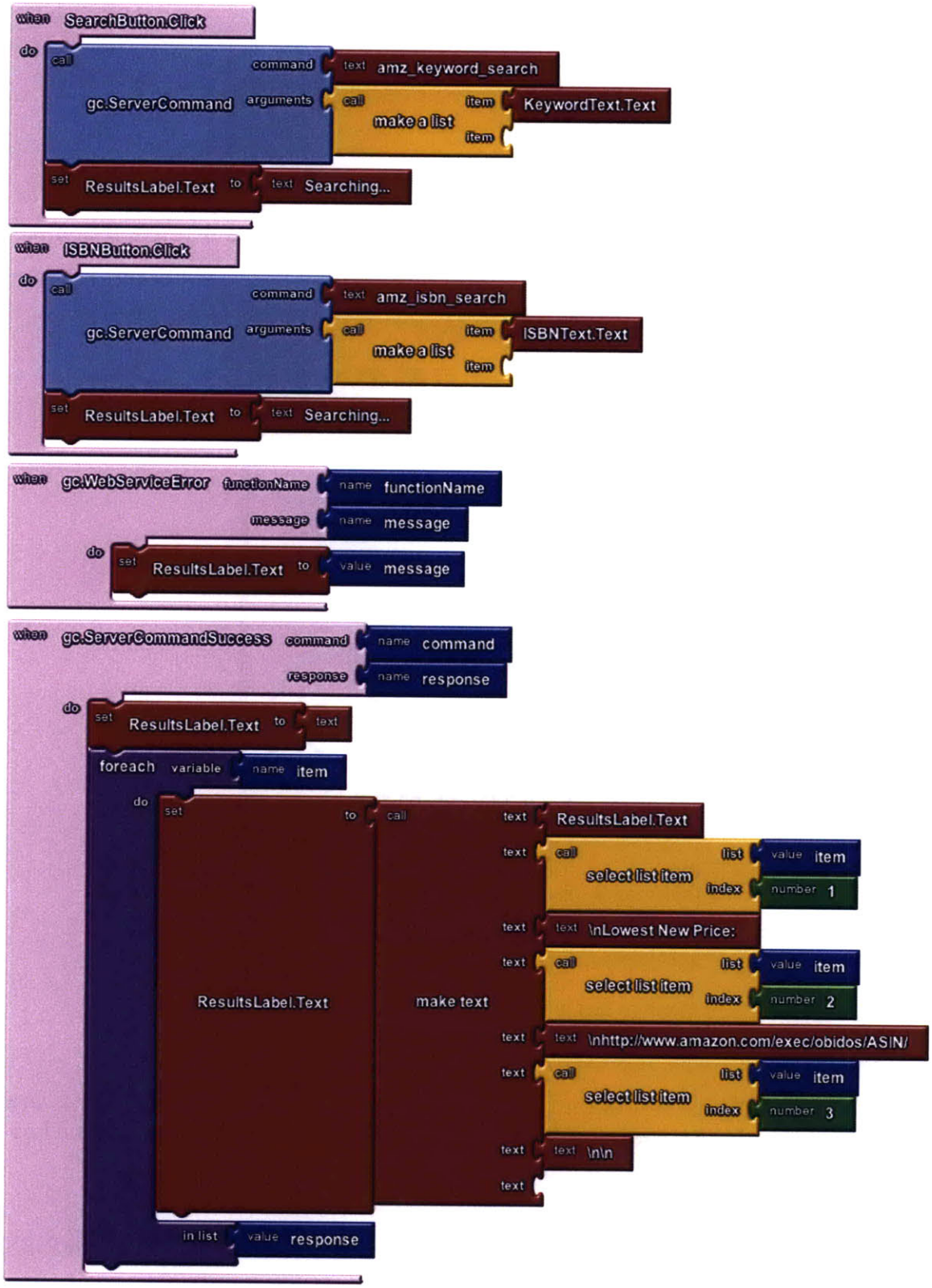


Figure 5-8: The entire blocks workspace for the Amazon program. By returning book information in the same format for both keyword and ISBN searches, all server command responses can be handled with the same blocks.

The returned results include each book's title, price on Amazon.com and the Amazon Standard Identification Number (ASIN). In order to keep the program logic simple, the server commands for searches by ISBN and keyword return their results in the same data format. This allows the ServerCommandReturned event handler to treat all server response lists identically. The entire blocks workspace of the Amazon program can be seen in Figure 5-8.

Access to the E-Commerce Services is done with a third-party Python library that accepts keywords or ISBNs and returns Python iterators of book objects. With this library, the server module only needs to format the results from the iterator into lists that can be returned to App Inventor. The resulting custom server module is less than 25 lines of Python code. The code for a keyword search is shown below (some documentation has been omitted for brevity).

5.2: Server code required to perform a search by keyword. (Excerpt from A.10)

```
1  def amazon_by_keyword(keyword):
2    """ Use the ecs library to search for books by keyword.
3
4    Returns:
5      A list of three-item lists. Each sublist represents
6      a result and includes the book title, its lowest found
7      price and its ASIN number.
8    """
9    ecs.setLicenseKey(license_key)
10   ecs.setSecretKey(secret_key)
11   ecs.setLocale('us')
12
13   books = ecs.ItemSearch(keyword, SearchIndex='Books', ResponseGroup='
       Medium')
14   return format_output(books)
15
16 def format_output(books):
17   """ Return a formatted output list from an iterator returned
18       by the ecs library. """
19
20   size = min(len(books), return_limit)
21   return [[books[i].Title, get_amount(books[i]), books[i].ASIN]
22           for i in xrange(size)]
23
24 def get_amount(book):
25   """ Return the lowest price found or 'Not found.' if none exists."""
26   try:
27     if book.OfferSummary and book.OfferSummary.LowestNewPrice:
28       return book.OfferSummary.LowestNewPrice.FormattedPrice
29   except:
```

```
30      return 'Not found.'
```

5.4 Androids to Androids

Androids to Androids is a multiplayer card game played by groups of three or more players[5]. Androids to Androids uses two different decks of cards:

- Noun Cards - Contain the name of a person, place or thing. A player's hand consists of seven noun cards at all times.
- Adjective Cards - Contain a description word. At the beginning of each round, an adjective card is chosen and displayed to all players. Players then choose the noun card that they think is the best match for the round's adjective and submit it to the leader.

When players first open the Androids to Androids program, they must either join a game or make their own. If a player creates a new game, that player is automatically the first leader of the game and must wait until at least two other players join his or her game before beginning. Once a game begins, it continues in rounds until one player reaches a score of five. The winner of each round is determined by the current round leader and is awarded one point. Each new round is led by the winner of the previous round. To start the game, each player is dealt seven noun cards.

At the beginning of each round, an adjective card is chosen at random by the server and sent to each player. Every player, except the leader, then chooses a noun card from his or her hand and submits it to the leader for review. When a player submits a card, the server will send it to the leader of the round and replenish the player's hand with a randomly chosen noun card from the deck. The server keeps track of the hands of all players in the game using the built-in card game server extension.

[5]Androids to Androids is a variant of the party game Apples to Apples published by Mattel.

To end a round, the leader selects a winner from the set of submitted noun cards. Players usually submit cards that apply thematically to the characteristic card for the round, although, the leader of a round is allowed to use any selection criteria he or she wish in determining the winner. Learning the selection preferences of other players is very important to apply proper strategy during the course of a game.

An example round with Bob, Alice and George would follow this rough script:

1. Bob has won the previous round and thus is the current leader.
2. All players receive the adjective card, "closed".
3. Alice submits the noun card, "apple".
4. George submits the noun card, "broken".
5. The leader refreshes his game state and receives the cards that Alice and George submitted. He decides to choose the "apple" card as the winner and submits it to the server.
6. The server looks up the "apple" card and finds out that it was submitted by Alice.
7. Alice receives a point and becomes the leader for the next round. All players are informed that Alice has won the round and are presented with a new adjective card.

5.4.1 Round Numbers

Games that proceed in rounds, such as Androids to Androids, present a unique design challenge because in order to work properly, all users must be in sync throughout the course of the game. To help solve this problem, the client keeps track of its view of the round number and includes it as an argument to each server command. If the locally stored value is ever less than the current value held on the

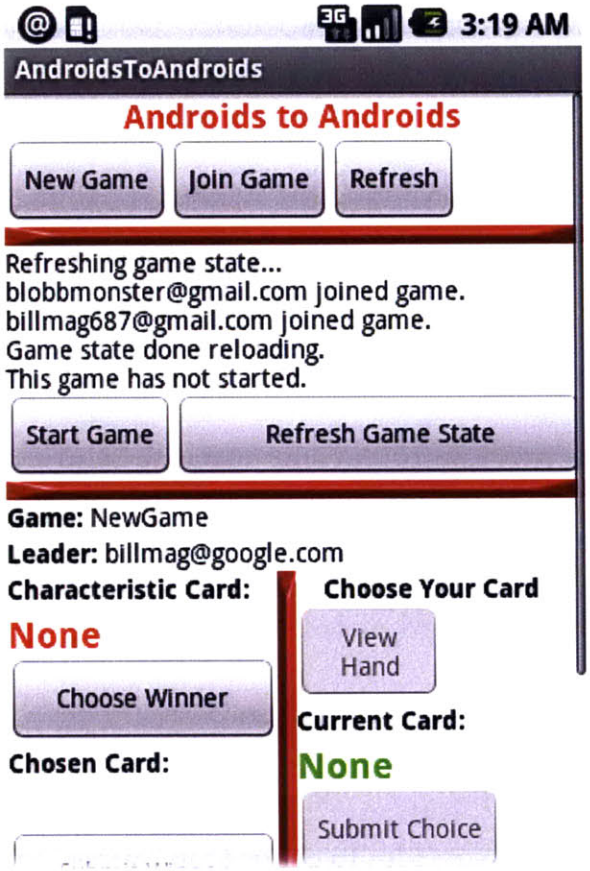


Figure 5-9: The user interface after two additional players have joined a new game. The "Start Game" button is activated and will send a server command to begin the game if clicked.

server, the server knows that the client has fallen behind and provides the current round's information. If this catch-up response is received, the client will ignore the action made by the player and instead re-sync with the server.

The code for submitting a card is shown below. The first check done by the server command is to make sure that the card has been submitted for the correct round. The user interface after a successful submission is shown in Figure 5-10.

5.3: The custom server command for submitting a noun card to the leader. (Excerpt from A.11)

```
1 def submit_card_command(instance, player, arguments):
2   """ Submit a noun card for the current round.
3
4   Args:
5     instance: The GameInstance database model for this operation.
6     player: The player submitting the card. Cannot be the leader.
```

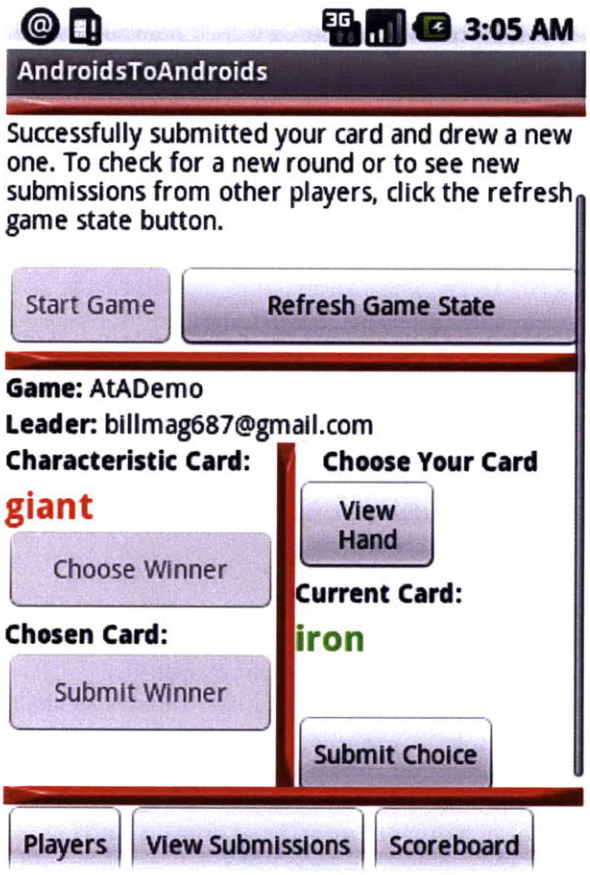


Figure 5-10: Androids to Androids after submitting a card. Players choose cards from their hand using a ListPicker component and submit them to the leader. In response to the card submission, the server will replenish the player's hand with a new card drawn randomly from the deck and send it back to him or her.

```
7       arguments: A two-item list consisting of the round to submit this
8         card for and the card itself.
9
10    If the submission is for the wrong round, a four-item list with an
11    error string as its first element will be returned.  The remaining
12    elements are the player's hand, the current round and the current
13    characteristic card to respond to. No other action will be taken.
14
15    Removes the indicated card from the player's hand and adds it
16    to this round's submissions. The current submissions are sent via
17    message to all players.
18
19    The requesting player's hand will be dealt another card after
20    removing the submitted one. The updated hand will be sent to the
21    requesting player in a message and be included in the return value
22    of this command.
23
24    Returns:
25      If the submission is for the correct round, returns a three-item
```

```
26      list consisting of the current round number, a list of the
27      submissions made so far by other players in this round and the
28      player's new hand.
29
30    Raises:
31      ValueError if player is the leader. The leader is not allowed to
32      submit cards.
33    """
34    if int(arguments[0]) != instance.ata_round:
35      hand = card_game.get_player_hand(instance, player)
36      return ['You tried to submit a card for the wrong round. ' +
37              'Please try again.', hand, instance.ata_round,
38              instance.ata_char_card]
39
40    if player == instance.leader:
41      raise ValueError("The leader may not submit a card.")
42
43    submission = arguments[1]
44    submissions = set_submission(instance, player, submission).values()
45    instance.create_message(player, 'ata_submissions', '',
46                            [instance.ata_round,
47                             submissions, submission]).put()
48
49    card_game.discard(instance, player, [submission], False)
50    hand = card_game.draw_cards(instance, player, 1)
51    return [instance.ata_round, submissions, hand]
```

5.4.2 Leaders

Androids to Androids makes use of a game leader to control the user interface and pass leadership of the game from player to player. Each time a request is made, the server includes the current leader in its reply. On the client, every response is checked and a NewLeader event is raised if the value of the leader parameter changes. The NewLeader event handler in Androids to Androids (see Figure 5-11) changes which parts of the user interface are enabled. This ensures that all players are performing the correct actions and not making inappropriate server calls. When a player wins a round, he or she automatically becomes the new leader and gets to choose winner of the next round.

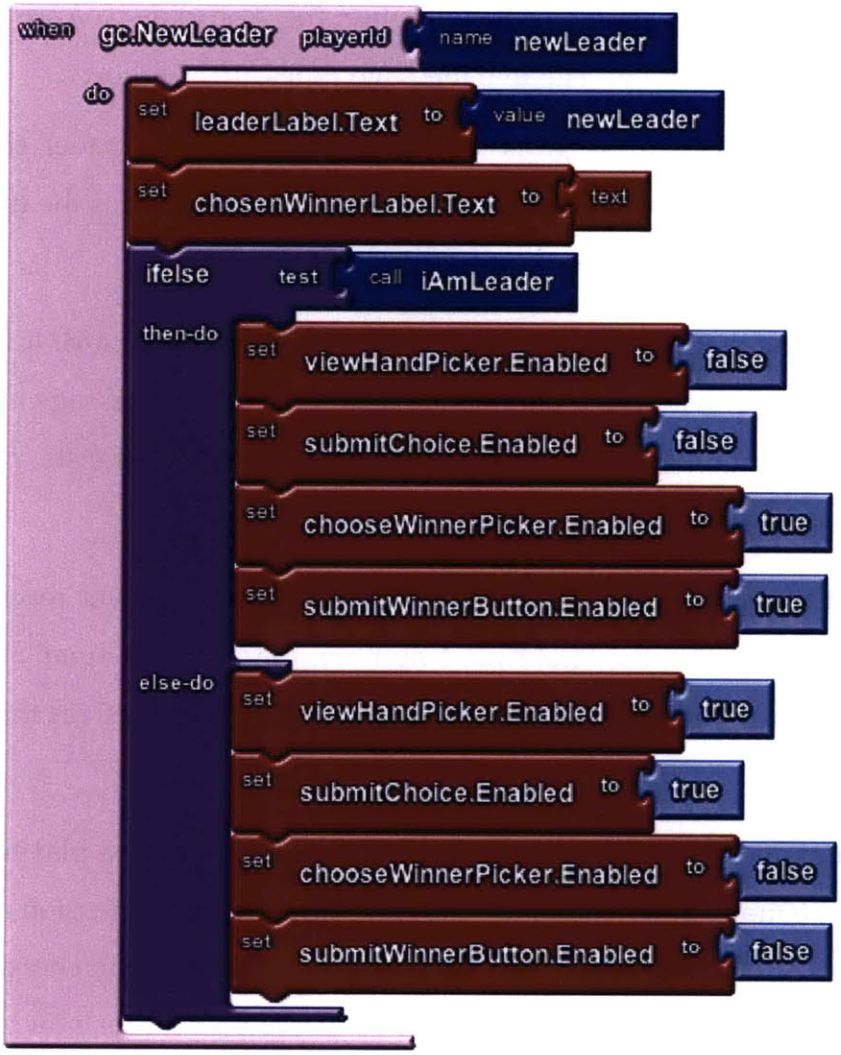


Figure 5-11: The Androids to Androids NewLeader event handler. The leader has a different set of actions than other players during a round. This event handler ensures that only necessary user interface elements are enabled for each player.

5.4.3 Messages and Persistent State

There are five different message types used in Androids to Androids. The first four are created by the custom server module and are sent to all players in the game. The fifth type is for players' hands. Hand messages are sent directly to the player from the card game extension when the Androids to Androids server module invokes its methods. The five message types are as follows:

- New Game - This message is sent to players after the leader clicks "Start Game" and the server initializes the game state. It includes the first round's characteristic card and the starting scoreboard.

- New Round - Each time the leader chooses a winning card, a new round starts with the winning player as the next leader. This message includes the new round number, the updated scoreboard, the characteristic card for the round, the winner's email and the winning card.

- Game Over - A Game Over message is sent when a player reaches a score of five. It includes the final round number, the winner's email address, the winning card and the final scoreboard. When a client receives this message, it allows the user to leave the game.

- Submissions - Submissions messages are sent whenever a player submits a card. The messages include the round number of the submission and a list of all cards submitted so far. This list is used by the leader to choose a winner and is provided to all players to view while they wait for others to submit noun cards.

- Hand - These messages are sent whenever a player's hand is modified from dealing, discarding or drawing cards. Every time a player submits a card, a new hand message is created. Figure 5-10 shows the user interface after a player has submitted a card and his or her hand has been replenished.

The use of messages in Androids to Androids allows players to close Androids to Androids at any time and later rejoin a game in progress. Reloading a game

Figure 5-12: The GotMessage event handler in Androids to Androids. Depending on the type of message received, the event handler calls another procedure with the message contents as the argument. These procedures know the specific format and ordering of the contents of their message type.

is possible because the current state of the game does not rely on persisted local state and can be recreated by processing game messages. With the five message types listed above, each time the game transitions from one state to another, there is a message created containing the information required to perform the transition. Taking advantage of this, the client was built as a state machine and updates its user interface as it receives messages. If the Androids to Androids program is exited and re-opened, it requests its previous messages and replays the game internally. The Game Client component will make sure that messages are received by the client in the order that they were created and provides their type to the GotMessage handler so that each one is handled properly. Figure 5-12 shows the GotMessage event handler that calls the appropriate procedure for each message type.

5.5 Summary

Each of the examples leverages the same set of Game Server capabilities to achieve different outcomes. All use some basic operations such as creating, joining and leaving instances, sending and fetching messages, changing the leader, retrieving instance lists and inviting players. The Bulletin Board application implements a multiuser chatting program without using a single server command or modifying the server in any way. Other programs, such as Amazon or MoBulls and Cows demonstrate that even with a few dozen lines of code, extra capabilities can be added to the Game Server by using custom modules. Finally, we see that with a bit more sophistication, but still using less than 150 lines of code, custom modules can implement more complicated games such as Androids to Androids.

Chapter 6

Related Research

Building Blocks for Mobile Games extends previous work in the fields of visual programming languages, game building, teaching with computer games, and multiuser mobile phone networks. This chapter discusses the design trade-offs of related projects as they compare to the implemented characteristics of the Building Blocks for Mobile Games multiplayer framework.

6.1 Visual Programming Languages

App Inventor follows in the footsteps of previous graphical programming languages, such as Scratch and StarLogoTNG, as a tool to allow users to build applications with graphical building blocks instead of textual code. App Inventor is unique among these languages in its targeting of the mobile phone platform and the breadth of its capabilities.

Scratch and StarLogoTNG use blocks languages similar in appearance and function to the language used in App Inventor. Under the hood, the App Inventor blocks editor runs with a modified version of the OpenBlocks library[11]. The OpenBlocks framework is a general purpose graphical blocks language that can be configured to meet the needs of many different graphical programming projects. StarLogoTNG, which the OpenBlocks framework is based on, is an evolution of the original StarLogo[10]. StarLogo and Scratch both share influences from the

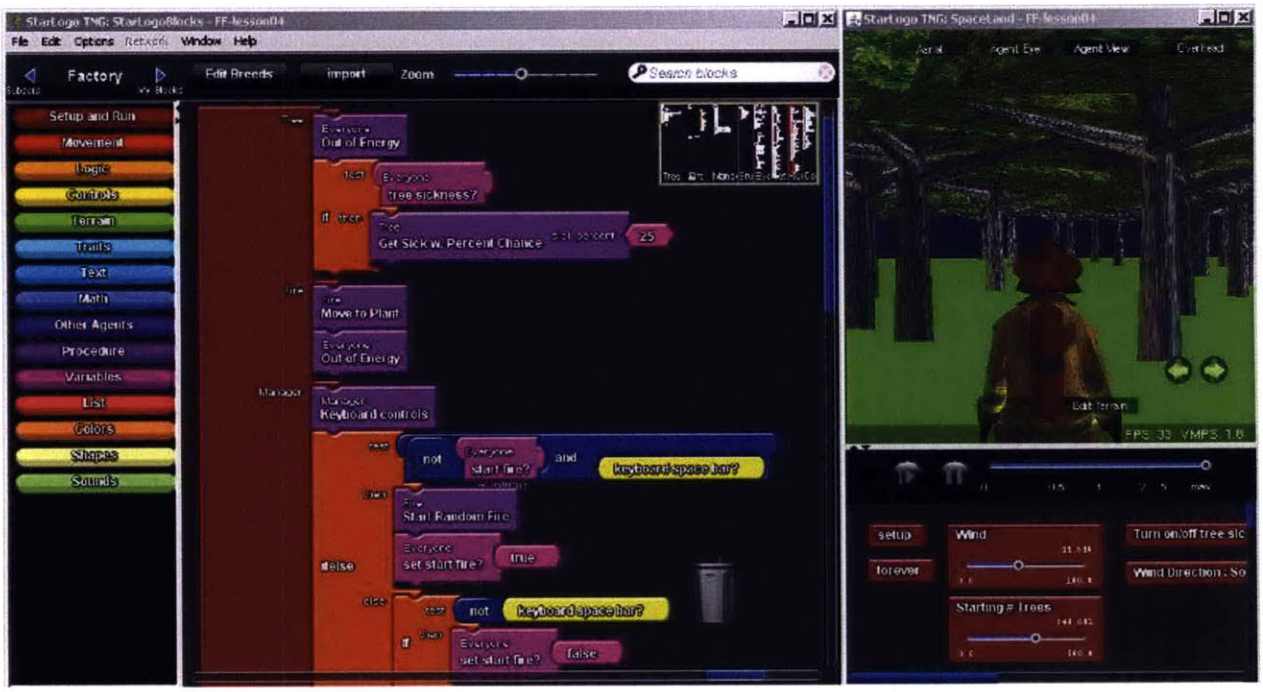


Figure 6-1: The user interface of StarLogoTNG. The blocks of StarLogoTNG closely resemble the blocks in App Inventor. A real time view of the running program is shown in the top right.

Logo programming language (a dialect of Lisp developed in the late 1960's).

Scratch, which is targeted primarily toward children, includes only basic operations in its blocks language. App Inventor, on the other hand, has multiple tiers of operations in order to satisfy users with different skill levels. The design challenges of creating multiplayer games and handling asynchronous function calls push the Game Client component into a higher tier of complexity. However, Building Blocks for Mobile Games remains accessible to beginning users by simplifying its server requests into single blocks which are easy for application creators to understand.

StarLogoTNG, along with Kodu[1] and Alice[2], allow users to create games with 3D graphics. Screenshots demonstrating the blocks languages of Alice and Kodu are shown in Figures 6-2 and 6-3. Game creators define event handlers and proce-

[1]Kodu is being developed by a team at Microsoft Research. It was initially released on June 30th 2009 for the Xbox 360 and is currently available for Windows through an invitation only system[3].

[2]Alice was started by Carnegie Mellon University. Electronic Arts and Sun Microsystems are providing development support for the most recent release, which is currently in beta and available for Windows, Linux and OS X[14].

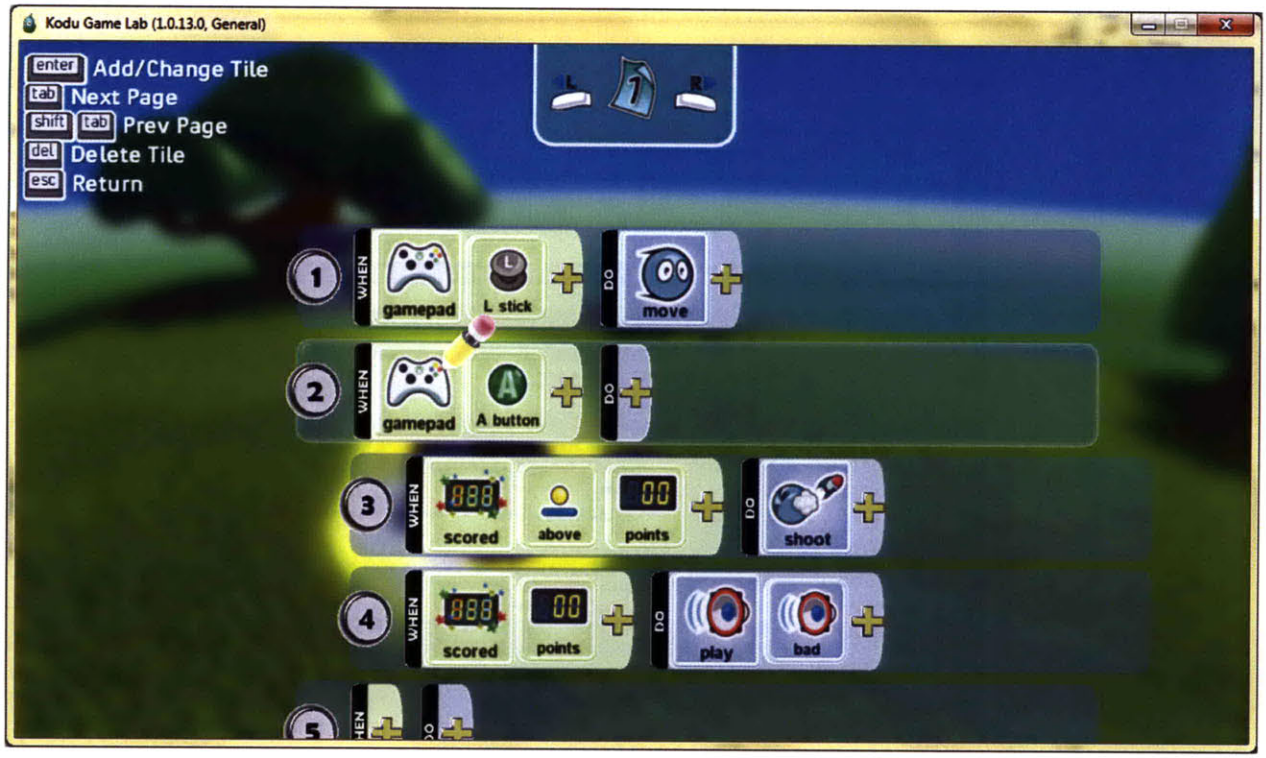


Figure 6-2: A procedure in Kodu. Kodu uses "when" and "do" blocks which operate equivalently to event handlers and method calls in App Inventor. Nested "when" blocks are used to implement conditionals.

dures which determine the behavior and reactions of 3D characters as they move about the game's 3D environment. These languages sidestep the complexity of creating graphics, but also limit the breadth of functionality that can be included in applications by focusing on working in the 3D environment.

Graphics in App Inventor are made using 2D image sprites and a drawing canvas. Graphics and user interface design in App Inventor are still at an early stage in development. As the platform matures it will include more graphics primitives to allow users to build more visually interesting applications.

6.2 Mobile Games in Education

Many educators use games to encourage students to take an active role in their studies. Recently, mobile games have been used in education to allow students to learn through engagement with their environment. One such system, built by

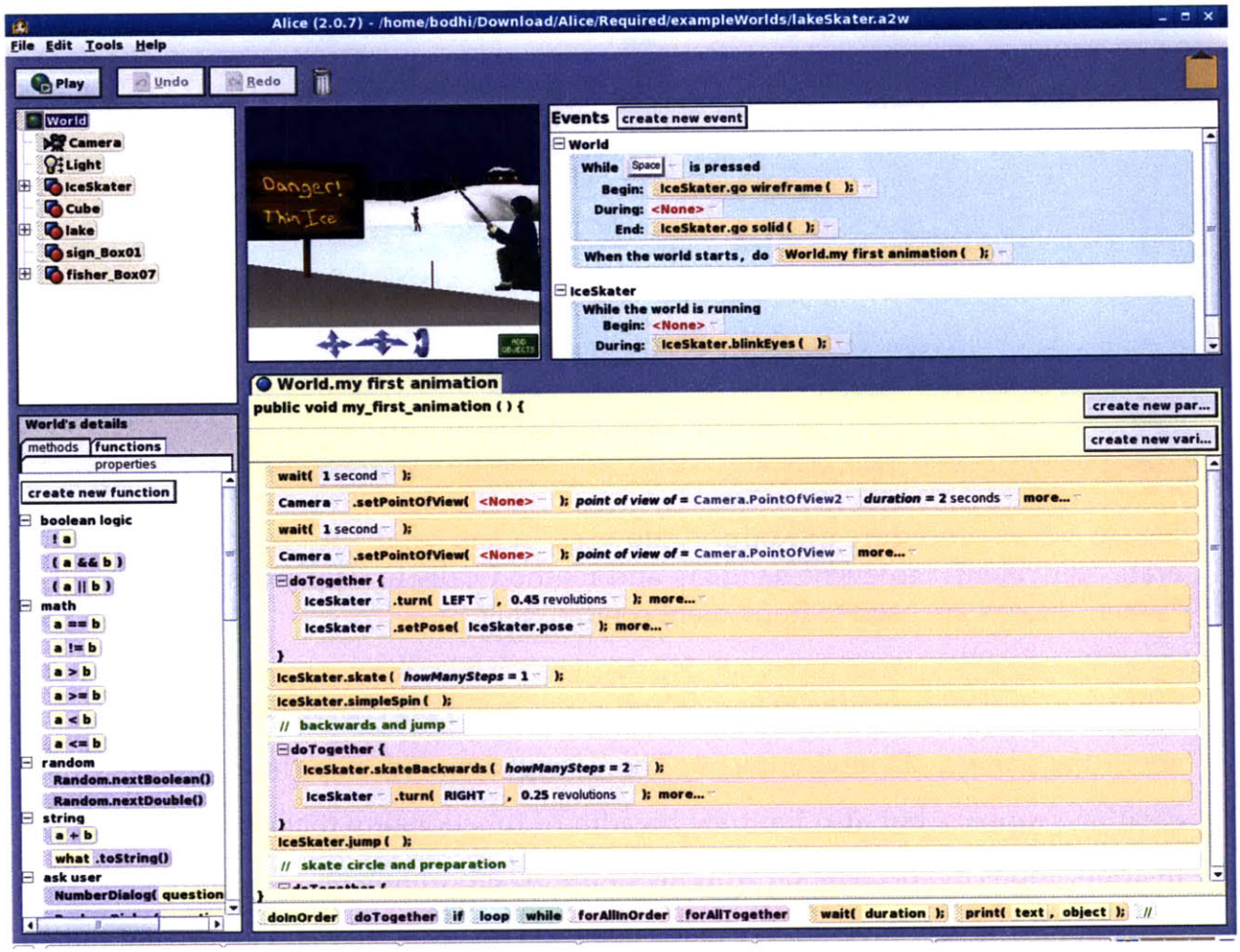


Figure 6-3: The user interface for Alice. Game creators define animations and event handlers which control the interaction of characters in a 3D environment using the guided storyboard. The display of semicolons and brackets is an optional feature of Alice that is used to transition users to Java or other written languages. The 3D animation displayed at the top of the window can be run to see the effect of changes to the storyboard during development.[4]

professors from three universities in Taiwan, uses a client-server setup similar to the Building Blocks for Mobile Games' design[12]. The design is aimed at allowing course instructors to provide lessons to their students, but makes no effort to give students the ability to easily customize the application on their own. Additionally, the lesson creator uses a rigid design structure, which limits the creativity of game creators.

The Department of Computer Science at Central Connecticut State University is also developing a new class that uses video game creation to introduce Computer Science to students. Encouraged by students' enthusiasm for computer games, but discouraged by the difficult task of teaching students the complexities of modern games; the course developers turned to mobile game design. Students are required to have a basic knowledge of Java before taking the class and are taught using the Java 2 Platform Micro Edition (J2ME)[9].

The course succeeded at teaching students to create single player games, however, most students expressed a desire to make multiplayer games by the end of the course. Unfortunately, course instructors found including multiplayer games in the curriculum to be difficult due to the the higher technical requirements of implementing data communication on mobile devices, and the breadth of prerequisite topics[9]. Both of these issues can likely be solved with App Inventor and Building Blocks for Mobile Games because the component system removes the ramp-up time required to teach students the J2ME platform and eliminates the need for students to implement data handling and server communication. However, this has not yet been tested in a real classroom environment.

6.3 Alternatives to Client-Server Design

Peer to peer overlays such as the Content Addressable Network (CAN) technique and Pastry have been used as aggregation tools for distributing game state among players in massive multiplayer online games (MMOGs). One of these, SimMud, uses Pastry to avoid the large start-up costs of a centralized server and handling

peak loads[8]. The Game Server addresses these resource problems by using the free App Engine service, which provides easy setup and automatic scaling of computing power to meet demand.

Researchers in Berlin performed an analysis of the use of the CAN technique for mobile gaming. The research, which was done in 2005, suggests that the increased use of 3rd generation protocols promotes a server-client over a peer to peer structure for mobile games, citing only cost to the user for data service subscriptions as a concern[5]. Most modern smartphones (and all Android mobile phones, which App Inventor is built for) are capable of using 3rd generation data networks and are generally sold with affordable, unlimited use data plans. Thus, these concerns have become outdated.

One fault that remains is the high latency and poor reliability of mobile connections. In practice, Android applications often fail to successfully complete requests. These conditions make playing real-time games nearly impossible as it is very difficult to maintain real-time game state on the client[5]. This problem can be avoided by creating turn based games and building server commands that properly handle duplicate requests.

Chapter 7

Extensions

While a wide range of games and interesting applications can already be created using App Inventor, there are many areas for improvement that will streamline the game creation process and allow users to create more advanced applications. Each extension listed below discusses the improvements and changes that can be made to the multiplayer framework as the App Inventor system matures.

7.1 User Interfaces and Multiple Screens

The main challenges for current games with respect to inviting players or managing game membership are related to cumbersome user interfaces. Currently, App Inventor only supports a single screen and a small selection of user interface components. Thus, game designers must include both the game management and game playing user interfaces on the same screen. This causes game interfaces to quickly become cluttered and confusing. A new player that opens the application will be tempted to immediately start using the game playing interface before he or she has even joined a game. Application designers can currently handle this by disabling parts of the user interface to shoehorn several different modes into a single screen, but this is often very confusing for users and requires a large number of blocks to implement. Future versions of App Inventor will include more powerful and diverse user interface capabilities.

7.2 Saving Local State

Another problem for application designers is dealing with the lack of persistent local state in App Inventor applications. Currently, when an application is interrupted it loses all of its state and completely re-initializes when it is reopened. During the course of a long lasting game, it is likely that the game will be interrupted by a phone call, text message or other activity on the phone.

The Game Server's messages and the TinyWebDB component can both be used to persist application state on the web, but in many cases components require state that is not exposed to the user as properties. In the Game Client component this includes a dictionary of message types to receipt times that is stored as a private hashmap in the component's Java code. Similarly, storing received messages, the text on a Label, or the elements of a ListPicker would all make dealing with game interruptions much easier.

One way to solve this is to create a way for component creators to register state variables with some kind of persistence manager. Then, whenever the program is interrupted or closed, all of the registered state is written to the SQLite database running on the phone.

7.3 Pushing Messages and Game State Updates

In the present design of the Game Server, applications are forced to poll the Game Server to receive new messages or to update game state information, such as the current players or the leader. Application developers can currently maintain an up-to-date view of the game state and messages by constantly repeating server requests with a Clock component or by triggering new calls immediately after a previous one returns. Unfortunately, this approach is ineffective and costly on a mobile phone. Mobile data connections are unreliable and often require round trip times measuring in seconds just to complete a single server request. Programs must also be careful not to use too much battery life or users will be unwilling to

run them.

In the future I expect the App Inventor system to support a way to push information to applications or create long-lived server connections. This would allow games to immediately become aware of new messages, lead changes, and new players. Building Blocks for Mobile Games is well suited to using this architecture because all game changes are caused by events performed by other players. If such a change was made, the method blocks for GetInstanceLists and GetMessages could be removed. Application design could then focus on what to do in response to the receipt of messages instead of trying to optimize data usage and performance by fine tuning when they should be retrieved.

Chapter 8

Contributions

The Building Blocks for Mobile Games multiplayer framework provided the following contributions:

1. Integrated a Game Client component into App Inventor for Android system which enables application developers to use the Game Server and other App Engine capabilities with App Inventor applications.

2. Built a Game Server with game management, message-passing, extensions, and custom module support using the Python App Engine SDK.

3. Developed four custom modules to show the integration of user created commands into the Game Server to implement game logic, leverage extensions, and access third-party data services.

4. Created five example applications to demonstrate the breadth of capabilities of the Building Blocks for Mobile Games multiplayer framework.

5. Utilized the Nose GAE testing system to create a unit test suite for the Game Server and its modules, which runs in the Google App Engine sandbox.

6. Released the Game Client and open source Game Server code through the App Inventor for Android Google Code project.

Appendix A

Game Server Code

This appendix includes the request handlers, database models, server extensions and custom modules written for the Game Server to run on App Engine. All unit tests and third-party code are omitted. For the complete runnable server code, see the App Inventor for Android project on Google Code at:
http://code.google.com/p/app-inventor-for-android/.

Files are organized in sections according to the directory structure of the Game Server. To view more documentation and download the example programs presented in this thesis please visit the App Inventor Help site at:
http://sites.google.com/site/appinventorhelp/.

A.1 Game Server

A.1: server.py - The Game Server application file. Includes the request handlers for server requests.

```
1  # Copyright 2010 Google Inc.
2  # Licensed under the Apache License, Version 2.0 (the "License");
3  # you may not use this file except in compliance with the License.
4  # You may obtain a copy of the License at
5
6  #      http://www.apache.org/licenses/LICENSE-2.0
7
8  # Unless required by applicable law or agreed to in writing, software
9  # distributed under the License is distributed on an "AS IS" BASIS,
```

```
10 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
       implied.
11 # See the License for the specific language governing permissions and
12 # limitations under the License.
13 """
14 Defines the request handlers for the game server. After retrieving
15 arguments from the request, all operations are run as database
16 transactions.  This means that any unhandled errors encountered
17 during the operations will result in the database performing a
18 'rollback' to the state that it was in before the request was made.
19
20 All server command functions return a tuple of the database model
21 they operated on and a dictionary of results. These vary from command
22 to command, but all requests will provide their return value using an
23 OperationResponse object.
24
25 The get functions for each request handler provide a simple web form
26 to perform the operation via a web interface and will write their
27 responses as a web page. Put functions write json to the request
28 handler that can be consumed by other applications.
29
30 Throughout this module, pid is accepted as an argument. The correct
31 format for a pid is of one of the following forms:
32 'Bill Magnuson' <billmag@mit.edu>
33 billmag@mit.edu
34
35 Received pids will be parsed for the email address and only the email
36 address will be used to identify players during game
37 operations. These same rules apply to other fields which identify
38 players such as a new leader or an invitee. In general, the variable
39 name 'player' will be used to represent values that are email
40 addresses and pid is used more generally to indicate that other
41 strings are acceptable as input.
42
43 For more information about the validation done on game ids, instance
44 ids, and player ids, look to utils.py.
45 """
46
47 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
48
49 import sys
50 import logging
51 import traceback
52 import iso8601
53 import utils
54 from datetime import datetime
55 from django.utils import simplejson
56 from google.appengine.ext import webapp
57 from google.appengine.ext.webapp.util import run_wsgi_app
58 from google.appengine.ext import db
59 from models.game import Game
60 from models.game_instance import GameInstance
61 from models.message import Message
62 from server_commands import command_dict
```

```
63
64  ####################
65  # Module Constants #
66  ####################
67  # Operation Response Keys
68  REQUEST_TYPE_KEY = 'request_type'
69  ERROR_KEY = 'e'
70  RESPONSE_KEY = 'response'
71  GAME_ID_KEY = 'gid'
72  INSTANCE_ID_KEY = 'iid'
73  PLAYERS_KEY = 'players'
74  LEADER_KEY = 'leader'
75
76  # Request Parameter Keys
77  PLAYER_ID_KEY = 'pid'
78  INVITEE_KEY = 'inv'
79  TYPE_KEY = 'type'
80  CONTENTS_KEY = 'contents'
81  COMMAND_KEY = 'command'
82  ARGS_KEY = 'args'
83  MESSAGE_COUNT_KEY = 'count'
84  MESSAGE_RECIPIENTS_KEY = 'mrec'
85  MESSAGE_TIME_KEY = 'mtime'
86  INSTANCE_PUBLIC_KEY = 'makepublic'
87
88  ####################
89  # Response Helpers #
90  ####################
91
92  def run_with_response_as_transaction(req_handler, operation, *args, **
        kwargs):
93    """ Run operation in a transaction and write its response to
       req_handler.
94
95    Args:
96      req_handler: The request handler to write a response to.
97      operation: The callable function to run as a transaction.
98      args: Positional arguments to pass to operation.
99      kwargs: Keyword arguments to pass to operation.
100
101   Runs operation as a database transaction, creates an
102   OperationResponse with the return value and writes it to the
103   request handler.
104
105   If an exception raises to this function a traceback is written to
106   the debug log and an OperationResponse is written to the request
107   handler with the error message as its contents and the error key
108   set to True.
109   """
110   try:
111     response = db.run_in_transaction(operation, *args, **kwargs)
112     OperationResponse(response = response).write_to_handler(
       req_handler)
113   except BaseException, e:
```

```
114       logging.debug('exception encountered: %s' % traceback.format_exc()
          )
115       OperationResponse(response = e.__str__(),
116                         error = True).write_to_handler(req_handler)
117
118   class OperationResponse():
119     """ Class for handling server operation responses and writing output
          .
120
121     An OperationResponse is a standard way to provide a response to a
122     server request. When operations are specific to a game instance,
123     the operation response includes information about the current state
124     of that instance.
125
126     If an error is encountered during an operation the
127     OperationResponse includes only the error boolean and the error's
128     message as its response.
129
130     Attributes:
131       error: A boolean indicating that an error occurred during the
132         execution of this operation.
133       gid: The game id of the game for this operation.
134       iid: The instance id of the game instance.
135       leader: The current leader of the game instance.
136       players: A list of players in the game instance
137     """
138     def __init__(self, response, error=False):
139       """ Fill in parameters based on the error value and the model
          returned.
140
141       Args:
142         response: If no error occurs, response should be a tuple of the
143           database model that this operation was performed with and a
144           dictionary representing the response value of the operation.
145           If an error is encountered, response should be an error
146           message.
147         error: A boolean indicating whether the operation encountered
148           an error during execution.
149
150       The OperationResponse's attributes are automatically filled in by
151       reading the attributes of the model in the response tuple. If the
152       model is a Game object then iid, leader and players are left with
153       empty values.
154       """
155       self.error = error
156       self.iid = ''
157       self.leader = ''
158       self.gid = ''
159       self.players = []
160
161       if self.error:
162         self.response = response
163       else:
164         model, self.response = response
```

```
165       if model and model.__class__.__name__ == 'GameInstance':
166         self.gid = model.parent().key().name()
167         self.iid = model.key().name()
168         self.leader = model.leader
169         self.players = model.players
170       elif model and model.__class__.__name__ == 'Game':
171         self.gid = model.key().name()
172
173   def write_to_handler(self, req_handler):
174     """ Writes a response to the req_handler.
175
176     Args:
177       req_handler: The request handler for this server request.
178
179     If the 'fmt' field of this request is 'html' then the response is
180     formatted to be written to the web. Otherwise, it is formatted to
181     be sent as json.
182     """
183     if req_handler.request.get('fmt') == 'html':
184       self.write_response_to_web(req_handler)
185     else:
186       self.write_response_to_phone(req_handler)
187
188   def write_response_to_web(self, req_handler):
189     """ Writes the response object to the request handler as html.
190
191     Args:
192       req_handler: The request handler for this server request.
193
194     Writes a web page displaying the response object as it would
195     be written to json.
196     """
197     req_handler.response.headers['Content-Type'] = 'text/html'
198     req_handler.response.out.write('<html><body>')
199     req_handler.response.out.write('''
200         <em>The server will send this to the component:</em>
201         <p />''')
202     req_handler.response.out.write(
203         self.get_response_object(req_handler.request.path))
204     req_handler.response.out.write('''
205     <p><a href="/">
206     <i>Return to Game Server Main Page</i>
207     </a>''')
208     req_handler.response.out.write('</body></html>')
209
210   def write_response_to_phone(self, req_handler):
211     """ Writes the response object to the request handler as json.
212
213     Args:
214       req_handler: The request handler for this server request.
215     """
216     req_handler.response.headers['Content-Type'] = 'application/json'
217     req_handler.response.out.write(
218         self.get_response_object(req_handler.request.path))
```

```
219
220     def get_response_object(self, request_type):
221       """ Return a JSON object as a string with the fields of this
        response.
222
223       Args:
224         request_type: The type of server request that caused this
225           operation.
226
227       Creates a dictionary out of the fields of this object and encodes
228       them in JSON.
229       """
230       response = simplejson.dumps({REQUEST_TYPE_KEY : request_type,
231                                    ERROR_KEY : self.error,
232                                    RESPONSE_KEY : self.response,
233                                    GAME_ID_KEY : self.gid,
234                                    INSTANCE_ID_KEY : self.iid,
235                                    LEADER_KEY : self.leader,
236                                    PLAYERS_KEY : self.players})
237       logging.debug('response object: %s' % response)
238       return response
239
240   ######################
241   # Operation Functions #
242   ######################
243
244   def get_instance_lists(gid, iid, pid):
245     """ Return the instances that a player has been invited to and
        joined.
246
247     Args:
248       gid: The game id of the Game object that this method targets.
249       iid: The instance id of the Game Instance object that this
250         method targets.
251       pid: A string containing the requesting player's email address.
252
253     The gid and pid must be valid, but the iid can be blank. This is
254     because a player must be able to query for lists of instances
255     without being in one.
256
257     Returns:
258       A tuple containing a database model and a dictionary of instance
259       lists.  The database model will be a Game Instance if the gid and
260       iid parameters specify a valid GameInstance, otherwise the model
261       will be a Game.  Instance lists are returned in the same format
262       as get_instance_lists_dictionary.
263
264     Raises:
265       ValueError if the game id or player id are invalid.
266     """
267     utils.check_gameid(gid)
268     player = utils.check_playerid(pid)
269     model = game = utils.get_game_model(gid)
270     if game is None:
```

```
271       game = Game(key_name = gid, instance_count = 0)
272       game.put()
273       model = game
274     elif iid:
275       instance = utils.get_instance_model(gid,iid)
276       if instance:
277         model = instance
278     instance_lists = get_instances_lists_as_dictionary(game, player)
279     return model, instance_lists
280
281 def invite_player(gid, iid, invitee):
282     """ Add invitee to the list of players invited to the specified
          instance.
283
284     Args:
285       gid: The game id of the Game object that this method targets.
286       iid: The instance id of the Game Instance object that this
287         method targets.
288       invitee: The player id of the person to invite.
289
290     Only modifies the instance if the player has not already been
291     invited and has not joined the game.
292
293     Returns:
294       A tuple of the game instance and a single item dictionary:
295         inv: The email address of the invited player if they are
296           invited. If the player is not invited (because they have
297           already been invited or have already joined the game), the
298           value of 'inv' is the empty string.
299
300     Raises:
301       ValueError if the game id, iid or invitee email address are
302       invalid.
303     """
304     utils.check_gameid(gid)
305     utils.check_instanceid(iid)
306     player = utils.check_playerid(invitee)
307     instance = utils.get_instance_model(gid, iid)
308     if player not in instance.invited and player not in instance.players
          :
309       instance.invited.append(player)
310       instance.put()
311     else:
312       player = ''
313     return instance, {INVITEE_KEY : player}
314
315
316 def join_instance(gid, iid, pid):
317     """ Attempt to add a player to an instance.
318
319     Args:
320       gid: The game id of the Game object that this method targets.
321       iid: The instance id of the Game Instance to join.
322       pid: A string containing the requesting player's email address.
```

```
323
324     A player can join a game instance if it is not full and either the
325     instance is public or the player has been invited. If this
326     operation is invoked by a player that is not current in the
327     specified instance and they are unable to join, it will fail.
328
329     If the player is already in the game instance this will succeed
330     without modifying the instance.
331
332     If the specified game instance doesn't exist, it will be created as
333     in new_instance with the specified instance id.
334
335     If no players are in the game when this player tries to join they
336     will automatically become the leader.
337
338     Returns:
339       A tuple of the game instance and the instance list dictionary
340       for this player (see get_instance_lists_as_dictionary).
341
342     Raises:
343       ValueError if the game id, instance id or player id are invalid.
344       ValueError if the player is not already in the game and is unable
345         to join.
346     """
347     utils.check_gameid(gid)
348     utils.check_instanceid(iid)
349     player = utils.check_playerid(pid)
350     instance = utils.get_instance_model(gid, iid)
351     if instance is None:
352       return new_instance(gid, iid, pid)
353     game = instance.parent()
354     instance_lists = get_instances_lists_as_dictionary(game, player)
355     instance.add_player(player)
356     instance.put()
357     if iid in instance_lists['invited']:
358       instance_lists['invited'].remove(instance.key().name())
359     if iid not in instance_lists['joined']:
360       instance_lists['joined'].append(instance.key().name())
361     return instance, instance_lists
362
363 def leave_instance(gid, iid, pid):
364     """ Remove a player from an instance.
365
366     Args:
367       gid: The game id of the game object that this method targets.
368       iid: The instance id of the Game Instance to remove the player
369         from.
370       player: The player wishing to leave the instance.
371
372     If the player that leaves the instance is the leader, the first
373     player on the players lists becomes the leader.
374
375     If no players are left, the maximum number of players allowed in
376     this instance is set to -1 so that no one may join it in the
```

```
377     future. This means that if someone tries to create an instance in
378     the future with the same instance id, they will end up with one with
379     a number appended to it (because this GameInstance object will still
380     exist).
381
382     The decision to do this was made because it is not yet possible to
383     reliably delete all of the messages in a game instance (see
384     models/game_instance.py). Thus, if players are able to join an
385     orphaned instances, the old messages could still be available. If,
386     in the future, App Engine adds ways to reliably delete database
387     models this behavior could be changed to delete the instance
388     entirely if everyone leaves.
389
390     Returns:
391       A tuple of the game object and the instance list dictionary
392       for this player (see get_instance_lists_as_dictionary).
393
394     Raises:
395       ValueError if the player is not currently in the instance.
396     """
397     utils.check_gameid(gid)
398     utils.check_instanceid(iid)
399     instance = utils.get_instance_model(gid, iid)
400     player = instance.check_player(pid)
401     instance.players.remove(player)
402     if player == instance.leader and len(instance.players) != 0:
403       instance.leader = instance.players[0]
404     if len(instance.players) == 0:
405       instance.max_players = -1
406     game = instance.parent()
407     instance_lists = get_instances_lists_as_dictionary(game, player)
408     instance_lists['joined'].remove(instance.key().name())
409     instance.put()
410     return game, instance_lists
411
412   def get_messages(gid, iid, message_type, recipient, count, time):
413     """ Retrieve messages matching the specified parameters.
414
415     Args:
416       gid: The game id of the Game object that is a parent of the
417         desired instance.
418       iid: This instance id of the Game Instance to fetch messages
419         from.
420       message_type: A string 'key' for the message. If message_type is
421         the empty string, all message types will be returned.
422       recipient: The player id of the recipient of the messages. This
423         operation will also return messages that are sent with an empty
424         recipient field.
425       count: The maximum number of messages to retrieve.
426       time: A string representation of the earliest creation time of a
427         message to returned. Must be in ISO 8601 format to parse
428         correctly.
429
430     Uses the get_messages function of the GameInstance class to
```

```
    retrieve messages.

    Returns:
      A tuple of the game instance and a dictionary with two items:
        'count': The number of messages returned.
        'messages': A list of the dictionary representations of the
          fetched messages.
    """
    utils.check_gameid(gid)
    utils.check_instanceid(iid)
    instance = utils.get_instance_model(gid, iid)
    recipient = instance.check_player(recipient)
    messages = instance.get_messages(count=count,
                                     message_type=message_type,
                                     recipient=recipient, time=time)
    return instance, {MESSAGE_COUNT_KEY : len(messages),
                      'messages' : messages}

def new_instance(gid, iid_prefix, pid, make_public = False):
    """ Create a new instance of the specified game.

    Args:
      gid: The game id of the Game parent of the new instance.
      iid_prefix: The desired instance id. If no instance has been made
        with this name before, then this will be the instance id of the
        newly created instance. However, since instance ids must be
        unique, the actual instance id will likely be iid_prefix with a
        number suffix.
      pid: The id of the first player and leader of the game.
      make_public: A boolean indicating whether this instance should
        be able to be seen and joined by anyone.

    The instance id will start with iid_prefix, but could have any
    suffix. If the parent Game object does not exist, it will
    automatically be created.

    Returns:
      A tuple of the newly created instance and an instance lists
      dictionary (see get_instance_lists_as_dictionary).

    Raises:
      ValueError if the gameid or player id are invalid.
    """
    utils.check_gameid(gid)
    player = utils.check_playerid(pid)
    game = Game.get_by_key_name(gid)
    if game is None:
      game = Game(key_name = gid, instance_count = 0)

    if not iid_prefix:
      iid_prefix = player + 'instance'
    instance = game.get_new_instance(iid_prefix, player)

    instance_lists = get_instances_lists_as_dictionary(game, player)
```

```
485     instance_lists['joined'].append(instance.key().name())
486     if make_public:
487       instance.public = True
488       instance_lists['public'].append(instance.key().name())
489     instance.put()
490     game.put()
491
492     return instance, instance_lists
493
494   def new_message(gid, iid, pid, message_type, message_recipients,
495                   message_content):
496     """ Create new messages and put them in the database.
497
498     Args:
499       gid: The game id of the Game parent of the instance to create a
500         message for.
501       iid: The instance id of the GameInstance to create a message for.
502       pid: The player id of the message sender.
503       message_type: A string that acts as a key for the message.
504       message_recipients: The recipients of the message formatted in
505         JSON. This can be a single player id as a JSON string, a list
506         of player ids in a JSON array or the empty string. Messages
507         sent with the empty string as a recipient can be fetched by
508         any player.
509       message_content: The string representation of a JSON value to be
510         sent as the content of the message.
511
512     Returns:
513       A tuple of the specified game instance and a dictionary with
514       two items:
515         'count' : The number of messages created.
516         'mrec' : The list of email addresses that were sent messages.
517
518     Raises:
519       ValueError if the requesting player or any of the message
520         recipients are not members of the specified game instance.
521     """
522     utils.check_gameid(gid)
523     utils.check_instanceid(iid)
524     instance = utils.get_instance_model(gid, iid)
525     player = instance.check_player(pid)
526     recipients_list = None
527     if message_recipients != '':
528       recipients_list = simplejson.loads(message_recipients)
529       if isinstance(recipients_list, basestring):
530         recipients_list = [recipients_list]
531     if not recipients_list:
532       recipients_list = ['']
533     message_list = []
534     for recipient_entry in recipients_list:
535       if recipient_entry:
536         recipient_entry = instance.check_player(recipient_entry)
537       message = Message(parent = instance,
538                         sender = player,
```

```
                        msg_type = message_type,
                        recipient = recipient_entry,
                        content = message_content)
      message_list.append(message)
    db.put(message_list)
    return instance, {MESSAGE_COUNT_KEY : len(message_list),
                      MESSAGE_RECIPIENTS_KEY : recipients_list}

def server_command(gid, iid, pid, command, arguments):
    """ Performs the desired server command.

    Args:
      gid: The game id of the Game model for this operation.
      iid: The instance id of the GameInstance model for
        this operation.
      pid: The player id of the requesting player.
      command: The key identifying the command to execute.
      arguments: JSON representation of arguments to the command.

    If the gid and iid specify a valid game instance model it will be
    passed to the server command. In the case that the iid is empty or
    refers to a game instance that doesn't exist, a game model will be
    used. Most commands will fail if passed a game model instead of a
    game instance, but some are indifferent to the model passed to
    them.

    Unless the dynamic property do_not_put has been set to False, this
    will put the database model after the command has been
    performed. This means that server commands do not need to make
    intermediate puts of the instance model passed to them.

    Returns:
      A tuple of the model used in the server command's execution and a
      two item dictionary:
        'type': The requested command key.
        'contents': A Python value of the response value of the
          command. This varies among server commands but must always be
          able to be encoded to JSON.

    Raises:
      ValueError if the game id or player id is invalid.
      ValueError if the arguments json cannot be parsed.
      ValueError if command is not a known server command.
    """
    utils.check_gameid(gid)
    player = utils.check_playerid(pid)
    model = None
    if iid:
      model = utils.get_instance_model(gid, iid)
    if model is None:
      model = utils.get_game_model(gid)
      if model is None:
        model = Game(key_name = gid, instance_count = 0)

```

```
593     arguments = simplejson.loads(arguments)
594     reply = ''
595
596     if command in command_dict:
597       reply = command_dict[command](model, player, arguments)
598       if 'do_not_put' not in model.dynamic_properties() or not model.
        do_not_put:
599         model.put()
600     else:
601       raise ValueError("Invalid server command: %s." % command)
602
603     if not isinstance(reply, list):
604       reply = [reply]
605     return model, {TYPE_KEY : command, CONTENTS_KEY: reply}
606
607   def set_leader(gid, iid, pid, leader):
608     """ Set the leader of the specified instance.
609
610     Args:
611       gid: The game id of the GameInstance object's parent Game object.
612       iid: The instance id of the GameInstance to change the leader of.
613       pid: The player id of the requesting player. This player must be
614         the current instance leader in oder to change the leader value.
615       leader: The player id of the new leader.
616
617     Returns:
618       A tuple of the change game instance model and a dictionary with
619       two items:
620         'current_leader' : The leader after attempting this change.
621         'leader_change' : Whether or not this attempt to set the leader
622           succeeded.
623     Raises:
624       ValueError if the game id or instance id are invalid.
625       ValueError if player or leader are not in the specified game
626         instance.
627     """
628     utils.check_gameid(gid)
629     utils.check_instanceid(iid)
630     instance = utils.get_instance_model(gid, iid)
631     player = instance.check_player(pid)
632     leader = instance.check_player(leader)
633     if player != instance.leader or instance.leader == leader:
634       return instance, {'current_leader' : instance.leader,
635                         'leader_changed' : False}
636     instance.leader = leader
637     instance.put()
638     return instance, {'current_leader' : leader,
639                       'leader_changed' : True}
640
641   def get_instance(gid, iid):
642     """ Retrieves an instance and its dictionary.
643
644     Args:
645       gid: The game id of the desired GameInstance object's parent Game
```

```
646         object.
647       iid: The instance id of the desired GameInstance object.
648
649     Returns:
650       A tuple of the game instance object and its dictionary
651       representation.
652
653     Raises:
654       ValueError if the game id or instance id are not valid.
655     """
656     utils.check_gameid(gid)
657     utils.check_instanceid(iid)
658     instance = utils.get_instance_model(gid, iid)
659     return instance, instance.to_dictionary()
660
661 ##################
662 # Writer Helpers #
663 ##################
664
665 def get_instances_lists_as_dictionary(game, player):
666     """ Return a dictionary with joined and invited instance id lists
        for player.
667
668     Args:
669       game: The Game database model that is the parent of the instances
670         to query.
671       player: The email address of the player to get instance lists for.
672
673     Returns:
674       A dictionary of lists:
675         'joined' : The list of instance ids of all all instances that
676           the player has joined and not subsequently left.
677         'invited' : The list of instance ids of all instances that the
678           player has been invited to and not yet joined.
679     """
680     return {'joined' : get_instances_joined(game, player),
681             'invited' : get_instances_invited(game, player),
682             'public' : get_public_instances(game)}
683
684 def get_instances_joined(game, player):
685     """ Return the instance ids of instance that player has joined.
686
687     Args:
688       game: The parent Game database model to query for instances.
689       player: The email address of the player to look for in instances.
690
691     Returns:
692       An empty list if game is None. Else, returns a list of the
        instance
693       ids of all instances with game as their parent that have player in
694       their joined list.
695     """
696     if game is None:
697       return []
```

```
698     query = game.get_joined_instance_keys_query(player)
699     return [key.name() for key in query]
700
701   def get_instances_invited(game, player):
702     """ Return the instance ids of instances that player has been
          invited to.
703
704     Args:
705       game: The parent Game database model to query for instances.
706       player: The email address of the player to look for in instances.
707
708     Returns:
709       An empty list if game is None. Else, returns a list of the
710       instance ids of all instances with game as their parent that have
711       player in their invited list.
712     """
713     if game is None:
714       return []
715     query = game.get_invited_instance_keys_query(player)
716     return [key.name() for key in query]
717
718   def get_public_instances(game):
719     """ Return the instance ids of public instances for the specified
          game.
720
721     Args:
722       game: The parent Game database model to query for instances.
723
724     Returns:
725       An empty list if game is None. Else, returns a list of the
726       instance ids of all joinable public instances with game as
727       their parent.
728     """
729     if game is None:
730       return []
731     query = game.get_public_instances_query(keys_only = True)
732     return [key.name() for key in query]
733
734   ############################
735   # Request Handler Classes #
736   ############################
737
738   class MainPage(webapp.RequestHandler):
739     """ The request handler for the index page of the game server. """
740     def get(self):
741       """Write a simple web page for displaying server information. """
742       self.response.headers['Content-Type'] = 'text/html'
743       self.response.out.write('<html><body>')
744       self.response.out.write('<h1>Game Server for App Inventor Game'
745           ' Client Component</h1>')
746       self.write_game_list()
747       self.write_methods()
748       self.response.out.write('''
749       <p><a href="http://appengine.google.com">
```

```
750       <small><i>Go to AppEngine Administration Console</i></small>
751       </a>''')
752       self.response.out.write('</body></html>')
753
754     def write_game_list(self):
755       """ Create an HTML table showing game instance information. """
756       self.response.out.write('''
757       <p><table border=1>
758         <tr>
759           <th>Created
760           <th>Game</th>
761           <th>Instance</th>
762           <th>Players</th>
763           <th>Invitees</th>
764           <th>Leader</th>
765           <th>Public</th>
766           <th>Max Players</th>
767           <th colspan="2">More ...</th>
768         </tr>''')
769       games = db.GqlQuery("SELECT * FROM GameInstance")
770       for game in games:
771         self.response.out.write(
772             '<tr><td>%s UTC</td>\n' % game.date.ctime())
773         self.response.out.write('<td>%s</td>' % game.parent().key().name
      ())
774         self.response.out.write('<td>%s</td>' % game.key().name())
775         self.response.out.write('<td>')
776         for player in game.players:
777           self.response.out.write(' %s' % player)
778         self.response.out.write('</td>\n')
779         self.response.out.write('<td>')
780         for invite in game.invited:
781           self.response.out.write(' %s' % invite)
782         self.response.out.write('</td>\n')
783         self.response.out.write('<td>')
784         self.response.out.write(' %s' % game.leader)
785         self.response.out.write('</td>\n')
786         self.response.out.write('<td>')
787         self.response.out.write(' %s' % game.public)
788         self.response.out.write('</td>\n')
789         self.response.out.write('<td>')
790         self.response.out.write(' %s' % game.max_players)
791         self.response.out.write('</td>\n')
792         self.response.out.write('''
793         <td><form action="/getinstance" method="post"
794               enctype=application/x-www-form-urlencoded>
795               <input type="hidden" name="gid" value="%s">
796               <input type="hidden" name="iid" value="%s">
797               <input type="hidden" name="fmt" value="html">
798               <input type="submit" value="Game state"></form></td>\n'''
      %
799                                   (game.parent().key().name(), game.key().
      name()))
800         self.response.out.write('</tr>')
```

```
801       self.response.out.write('</table>')
802
803     def write_methods(self):
804       """ Write links to the available server request pages. """
805       self.response.out.write('''
806           <p />Available calls:\n
807           <ul>
808           <li><a href="/newinstance">/newinstance</a></li>
809           <li><a href="/invite">/invite</a></li>
810           <li><a href="/joininstance">/joininstance</a></li>
811           <li><a href="/leaveinstance">/leaveinstance</a></li>
812           <li><a href="/newmessage">/newmessage</a></li>
813           <li><a href="/messages">/messages</a></li>
814           <li><a href="/setleader">/setleader</a></li>
815           <li><a href="/getinstance">/getinstance</a></li>
816           <li><a href="/getinstancelists">/getinstancelists</a></li>
817           <li><a href="/servercommand">/servercommand</a></li>
818           </ul>''')
819
820   class GetInstanceLists(webapp.RequestHandler):
821     """ Request handler for the get_instance_lists operation. """
822     def post(self):
823       """ Execute get_instance_lists and write the response to the
        handler.
824
825       Request parameters:
826         gid: The game id of the parent Game to get instances of.
827         iid: The instance id of the game instance to execute the
828           command with. This is optional for this command, although,
829           including it will result in the ResponseObject including
830           leader and player information.
831         pid: The player id of the requesting player.
832       """
833       logging.debug('/getinstancelists?%s\n|%s|' %
834                     (self.request.query_string, self.request.body))
835       gid = self.request.get(GAME_ID_KEY)
836       iid = self.request.get(INSTANCE_ID_KEY)
837       pid = self.request.get(PLAYER_ID_KEY)
838       run_with_response_as_transaction(self, get_instance_lists, gid,
        iid, pid)
839
840     def get(self):
841       """ Write a short HTML form to perform a get_instance_lists
        operation."""
842       self.response.out.write('''
843       <html><body>
844       <form action="/getinstancelists" method="post"
845             enctype=application/x-www-form-urlencoded>
846         <p>Game ID <input type="text" name="gid" /></p>
847         <p>Instance ID <input type="text" name="iid" /></p>
848         <p>Player ID <input type="text" name="pid" /></p>
849         <input type="hidden" name="fmt" value="html">
850         <input type="submit" value="Get Instance Lists">
851       </form>''')
```

```
852     self.response.out.write('</body></html>\n')
853
854 class GetMessages(webapp.RequestHandler):
855   """ Request handler for the get_messages operation. """
856   def post(self):
857     """ Execute get_messages and write the response to the handler.
858
859     Request parameters:
860       gid: The game id of the parent Game.
861       iid: The instance id of the game instance to execute the
862         command with.
863       pid: The player id of the message recipient.
864       type: The type of messages requested or the empty string to
865         retrieve all messages.
866       count: An integer number of messages to retrieve. This is
867         treated as a maximum and defaults to 1000 if there is a
868         failure retrieving the count parameter.
869       mtime: A string in ISO 8601 date format. All messages returned
870         will have a creation time later than this time. Defaults to
871         datetime.min if there is a failure in retrieving or parsing
872         the parameter.
873     """
874     logging.debug('/messages?%s\n|%s|' %
875                   (self.request.query_string, self.request.body))
876     gid = self.request.get(GAME_ID_KEY)
877     iid = self.request.get(INSTANCE_ID_KEY)
878     message_type = self.request.get(TYPE_KEY)
879     recipient = self.request.get(PLAYER_ID_KEY)
880
881     count = 1000
882     try:
883       count = int(self.request.get(MESSAGE_COUNT_KEY))
884     except ValueError:
885       pass
886
887     time = datetime.min
888     try:
889       time_string = self.request.get(MESSAGE_TIME_KEY)
890       if time_string is not None and time_string != '':
891         time = iso8601.parse_date(time_string)
892     except ValueError:
893       pass
894
895     run_with_response_as_transaction(self, get_messages, gid, iid,
896                                      message_type, recipient, count,
    time)
897
898   def get(self):
899     """ Write a short HTML form to perform a get_messages operation.
    """
900     self.response.out.write('''
901     <html><body>
902     <form action="/messages" method="post"
903           enctype=application/x-www-form-urlencoded>
```

```
        <p>Game ID <input type="text" name="gid" /></p>
        <p>Instance ID <input type="text" name="iid" /></p>
        <p>Message type <input type="text" name="type" /> </p>
        <p>Email <input type="text" name="pid" /> </p>
        <p>Count <input type="text" name="count" /> </p>
        <p>Time <input type="text" name="mtime" /> </p>
        <input type="hidden" name="fmt" value="html">
        <input type="submit" value="Get Messages">
      </form></body></html>\n''')

class InvitePlayer(webapp.RequestHandler):
  """ Request handler for the invite_player operation."""
  def post(self):
    """ Execute invite_player and write the response to the handler.

    Request parameters:
      gid: The game id of the parent Game.
      iid: The instance id of the game instance to invite the
        player to.
      pid: The player id of the requesting player.
      inv: The player id of the player to invite.
    """
    logging.debug('/invite?%s\n|%s|' %
                  (self.request.query_string, self.request.body))
    gid = self.request.get(GAME_ID_KEY)
    iid = self.request.get(INSTANCE_ID_KEY)
    inv = self.request.get(INVITEE_KEY)
    run_with_response_as_transaction(self, invite_player, gid, iid,
     inv)

  def get(self):
    """ Write a short HTML form to perform an invite_player operation.
    """
    self.response.out.write('''
    <html><body>
    <form action="/invite" method="post"
          enctype=application/x-www-form-urlencoded>
        <p>Game ID <input type="text" name="gid" /></p>
        <p>Instance ID <input type="text" name="iid" /></p>
        <p>Player ID <input type="text" name="pid" /></p>
        <p>Invitee <input type="text" name="inv" /> </p>
        <input type="hidden" name="fmt" value="html">
        <input type="submit" value="Invite player">
    </form>''')
    self.response.out.write('</body></html>\n')

class JoinInstance(webapp.RequestHandler):
  """ Request handler for the join_instance operation."""
  def post(self):
    """ Execute join_instance and write the response to the handler.

    Request parameters:
      gid: The game id of the parent Game.
      iid: The instance id of the game instance to join.
```

```
956         pid: The player id of the requesting player.
957       """
958       logging.debug('/joininstance?%s\n|%s|' %
959                     (self.request.query_string, self.request.body))
960       gid = self.request.get(GAME_ID_KEY)
961       iid = self.request.get(INSTANCE_ID_KEY)
962       pid = self.request.get(PLAYER_ID_KEY)
963       run_with_response_as_transaction(self, join_instance, gid, iid,
          pid)
964
965     def get(self):
966       """ Write a short HTML form to perform a join_instance operation.
          """
967       self.response.out.write('''
968       <html><body>
969       <form action="/joininstance" method="post"
970             enctype=application/x-www-form-urlencoded>
971         <p>Game ID <input type="text" name="gid" /></p>
972         <p>Instance ID <input type="text" name="iid" /></p>
973         <p>Player ID <input type="text" name="pid" /> </p>
974         <input type="hidden" name="fmt" value="html">
975         <input type="submit" value="Join Instance">
976       </form>''')
977       self.response.out.write('</body></html>\n')
978
979   class LeaveInstance(webapp.RequestHandler):
980     """ Request handler for the leave_instance operation."""
981     def post(self):
982       """ Execute leave_instance and write the response to the handler.
983
984       Request parameters:
985         gid: The game id of the parent Game.
986         iid: The instance id of the game instance to leave.
987         pid: The player id of the requesting player.
988       """
989       logging.debug('/leaveinstance?%s\n|%s|' %
990                     (self.request.query_string, self.request.body))
991       gid = self.request.get(GAME_ID_KEY)
992       iid = self.request.get(INSTANCE_ID_KEY)
993       pid = self.request.get(PLAYER_ID_KEY)
994       run_with_response_as_transaction(self, leave_instance, gid, iid,
          pid)
995
996     def get(self):
997       """ Write a short HTML form to perform a leave_instance operation.
          """
998       self.response.out.write('''
999       <html><body>
1000      <form action="/leaveinstance" method="post"
1001            enctype=application/x-www-form-urlencoded>
1002        <p>Game ID <input type="text" name="gid" /></p>
1003        <p>Instance ID <input type="text" name="iid" /></p>
1004        <p>Player ID <input type="text" name="pid" /> </p>
1005        <input type="hidden" name="fmt" value="html">
```

```
      <input type="submit" value="Leave Instance">
    </form>''')
    self.response.out.write('</body></html>\n')


class NewInstance(webapp.RequestHandler):
  """ Request handler for the new_instance operation."""
  def post(self):
    """ Execute new_instance and write the response to the handler.

    Request parameters:
      gid: The game id of the parent Game.
      iid: The proposed instance id of the new instance. The instance
        id of the created instance could differ from this if the
        proposed id is already in use.
      pid: The player id of the requesting player.
      make_public: A boolean indicating whether this instance should
        be able to be seen and joined by anyone.
    """
    logging.debug('/newinstance?%s\n|%s|' %
                  (self.request.query_string, self.request.body))
    gid = self.request.get(GAME_ID_KEY)
    iid = self.request.get(INSTANCE_ID_KEY)
    pid = self.request.get(PLAYER_ID_KEY)
    make_public = False
    try:
      make_public = utils.get_boolean(self.request.get(
    INSTANCE_PUBLIC_KEY))
    except ValueError:
      pass
    run_with_response_as_transaction(self, new_instance, gid, iid,
      pid, make_public)

  def get(self):
    """ Write a short HTML form to perform a new_instance operation.
    """
    self.response.out.write('''
    <html><body>
    <form action="/newinstance" method="post"
          enctype=application/x-www-form-urlencoded>
       <p>Game ID <input type="text" name="gid" /></p>
       <p>Instance ID <input type="text" name="iid" /></p>
       <p>First player ID <input type="text" name="pid" /></p>
       <input type="hidden" name="fmt" value="html">
       <input type="submit" value="New Instance">
    </form></body></html>\n''')

class NewMessage(webapp.RequestHandler):
  """ Request handler for the new_message operation. """
  def post(self):
    """ Execute new_message and write the response to the handler.

    Request parameters:
      gid: The game id of the parent Game.
```

```
      iid: The instance id of the game instance add messages to.
      pid: The player id of the requesting player.
      type: The message type key.
      mrec: Json representation of the recipients of the message.
      content: Json representation of the contents of the message.
    """
    logging.debug('/newmessage?%s\n|%s|' %
                  (self.request.query_string, self.request.body))
    gid = self.request.get(GAME_ID_KEY)
    pid = self.request.get(PLAYER_ID_KEY)
    iid = self.request.get(INSTANCE_ID_KEY)
    message_type = self.request.get(TYPE_KEY)
    message_recipients = self.request.get(MESSAGE_RECIPIENTS_KEY)
    message_content = self.request.get(CONTENTS_KEY)
    run_with_response_as_transaction(self, new_message, gid, iid, pid,
                                     message_type, message_recipients,
                                     message_content)

  def get(self):
    """ Write a short HTML form to perform a new_message operation."""
    self.response.out.write('''
    <html><body>
    <form action="/newmessage" method="post"
          enctype=application/x-www-form-urlencoded>
      <p>Game ID <input type="text" name="gid" /></p>
      <p>Instance ID <input type="text" name="iid" /></p>
      <p>Player ID <input type="text" name="pid" /></p>
      <p>Message type <input type="text" name="type" /> </p>
      <p>Message Recipients (Json array) <input type="text" name="
    mrec" />
      </p>
      <p>Message Contents (Json array) <input type="text" name="
    contents" />
      </p>
      <input type="hidden" name="fmt" value="html">
      <input type="submit" value="Send Message">
    </form>''')
    self.response.out.write('''<p> Expected format for recipients: <br
    >
                            ["email@domain.com", "email2@domain.com"]
    </p>''')
    self.response.out.write('''<p> Expected format for contents: <br>
                            ["string 1", "string 2"] </p>''')
    self.response.out.write('''</body></html>\n''')


class ServerCommand(webapp.RequestHandler):
  """ Request handler for the server_command operation. """
  def post(self):
    """ Execute server_command and write the response to the handler.

    Request parameters:
      gid: The game id of the parent Game to execute the command
        with.
```

```
      iid: The instance id of the game instance to execute the
        command with.
      pid: The player id of the requesting player.
      command: The key of the command.
      arguments: Json representation of the arguments to the
        server command.
    """
    logging.debug('/servercommand?%s\n|%s|' %
                  (self.request.query_string, self.request.body))
    gid = self.request.get(GAME_ID_KEY)
    iid = self.request.get(INSTANCE_ID_KEY)
    pid = self.request.get(PLAYER_ID_KEY)
    command = self.request.get(COMMAND_KEY)
    arguments = self.request.get(ARGS_KEY)
    run_with_response_as_transaction(self, server_command, gid, iid,
    pid,
                                     command, arguments)

  def get(self):
    """ Write a short HTML form to perform a set_leader operation."""
    self.response.out.write('''
    <html><body>
    <form action="/servercommand" method="post"
          enctype=application/x-www-form-urlencoded>
      <p>Game ID <input type="text" name="gid" /></p>
      <p>Instance ID <input type="text" name="iid" /></p>
      <p>Player ID <input type="text" name="pid" /> </p>
      <p>Command <input type="text" name="command" /> </p>
      <p>Arguments (Json array) <input type="text" name="args" /> </p
    >
      <input type="hidden" name="fmt" value="html">
      <input type="submit" value="Send Command">
    </form>''')
    self.response.out.write('''</body></html>\n''')

class SetLeader(webapp.RequestHandler):
  """ Request handler for the set_leader operation.  """
  def post(self):
    """ Execute set_leader and write the response to the handler.

    Request parameters:
      gid: The game id of the parent Game.
      iid: The instance id of the game instance to change the
        leader of.
      leader: The player id of the new leader candidate.
      pid: The player id of the requesting player.
    """
    logging.debug('/setleader?%s\n|%s|' %
                  (self.request.query_string, self.request.body))
    gid = self.request.get(GAME_ID_KEY)
    iid = self.request.get(INSTANCE_ID_KEY)
    leader = self.request.get(LEADER_KEY)
    pid = self.request.get(PLAYER_ID_KEY)
```

```
    run_with_response_as_transaction(self, set_leader, gid, iid, pid,
    leader)

  def get(self):
    """ Write a short HTML form to perform a set_leader operation."""
    self.response.out.write('''
    <html><body>
    <form action="/setleader" method="post"
          enctype=application/x-www-form-urlencoded>
       <p>Game ID <input type="text" name="gid" /></p>
       <p>Instance ID <input type="text" name="iid" /></p>
       <p>Player ID <input type="text" name="pid" /></p>
       <p>New leader (player id) <input type="text" name="leader" />
    </p>
       <input type="hidden" name="fmt" value="html">
       <input type="submit" value="Set leader">
    </form>''')
    self.response.out.write('</body></html>\n')

##############################################
# Handlers not used by GameClient component #
##############################################

class GetInstance(webapp.RequestHandler):
  """ Request handler for the get_instance operation."""
  def post(self):
    """ Execute get_instance and write the response to the handler.

    Request parameters:
      gid: The game id of the parent Game.
      iid: The instance id of the game instance to get the
        information of.
    """
    logging.debug('/getinstance?%s\n|%s|' %
                  (self.request.query_string, self.request.body))
    gid = self.request.get(GAME_ID_KEY)
    iid = self.request.get(INSTANCE_ID_KEY)
    run_with_response_as_transaction(self, get_instance, gid, iid)

  def get(self):
    """ Write a short HTML form to perform a get_instance operation.
    """
    self.response.out.write('''
    <html><body>
    <form action="/getinstance" method="post"
          enctype=application/x-www-form-urlencoded>
       <p>Game ID <input type="text" name="gid" /></p>
       <p>Instance ID <input type="text" name="iid" /></p>
       <input type="hidden" name="fmt" value="html">
       <input type="submit" value="Get Instance Info">
    </form>''')
    self.response.out.write('</body></html>\n')

##########################
```

```
# Application definition #
##########################

def application(custom_command_dict):
  """ Return the WSGI Application with the game server request
   handlers.

  Args:
    custom_command_dict: A dictionary of command name strings
      to functions.

  The custom_command_dict will be added to the server's command
  dictionary so that custom commands can be invoked with the
  ServerCommand request handler. If command names in
  custom_command_dict are the same as built in server commands they
  will overwrite the built in functions.
  """
  for command in custom_command_dict.iteritems():
    command_dict[command[0]] = command[1]
  return webapp.WSGIApplication([('/', MainPage),
                                 ('/newinstance', NewInstance),
                                 ('/invite', InvitePlayer),
                                 ('/joininstance', JoinInstance),
                                 ('/leaveinstance', LeaveInstance),
                                 ('/newmessage', NewMessage),
                                 ('/getinstancelists',
   GetInstanceLists),
                                 ('/messages', GetMessages),
                                 ('/setleader', SetLeader),
                                 ('/servercommand', ServerCommand),
                                 ('/getinstance', GetInstance)],
                                debug=True)
```

A.2: server_commands.py - Contains the server command dictionary and built-in server commands relating to instance management.

```
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# you may not use this file except in compliance with the License.
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#      http://www.apache.org/licenses/LICENSE-2.0

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# distributed under the License is distributed on an "AS IS" BASIS,
# WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
   implied.
# See the License for the specific language governing permissions and
# limitations under the License.
"""
Contains the server commands dictionary as well as the implementation
of a number of server commands related to instance management. More
```

```
16 specific server commands are in the extensions folder.
17
18 To enable server commands, they must be entered into
19 commands_dict. Every server command should take in a database model
20 (either a game instance or a game), the email address of the player
21 that requested the server command and a list of arguments. The format
22 of the arguments and what is done with the player and the database
23 model depends on the command.
24
25 Server commands should be generally useful to creators of games and
26 not be created for a specific game. Additionally, command functions
27 should, where appropriate, only parse the arguments and perform their
28 actual operations in separate methods. This allows for custom modules
29 to utilize extensions more easily when creating game specific
30 functions.
31 """
32
33 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
34
35 import logging
36 import traceback
37 import utils
38 from google.appengine.api import mail
39 from google.appengine.ext import db
40 from google.appengine.runtime import apiproxy_errors
41 from django.utils import simplejson
42 from extensions import scoreboard
43 from extensions import card_game
44
45 EMAIL_SENDER = ""
46
47 def send_email_command(model, player, arguments):
48   """ Send an email using App Engine's email server.
49
50   Args:
51     instance: Not used, can be any value.
52     player: The player requesting that the email be sent.
53     arguments: A two item list with the subject of the email as the
54       first item and the body of the email as the second.
55
56   EMAIL_SENDER must be defined above and be a listed developer
57   of your AppEngine application for this to work successfully.
58
59   Returns:
60     True if the email sends succesfully, False otherwise.
61   """
62   if email_sender:
63     message_recipient = arguments[0]
64     message_content = arguments[1]
65     mail.send_mail(sender=EMAIL_SENDER,
66                    to=message_recipient,
67                    subject=message_content[0],
68                    body=message_content[1] +
69                    '\nMessage sent from AppInventorGameServer by ' +
```

```
70                      player + '.')
71      return True
72    return False
73
74  def set_public_command(instance, player, arguments):
75    """ Set the public membership field for an instance.
76
77    Args:
78      instance: The GameInstance database model to change.
79      player: The player requesting the change. This player must
80        be the current leader of the instance.
81      arguments: A single item list containing the desired
82        boolean value for the public field of instance.
83
84    A public game can be joined by players without first being
85    invited. Changing the value of public does not change the current
86    membership of the game.
87
88    Returns:
89      The new value of public for the instance.
90
91    Raises:
92      ValueError if the requesting player is not the leader of the
93        instance.
94      ValueError if the argument is unable to be parsed into a boolean.
95    """
96    instance.check_leader(player)
97    value = utils.get_boolean(arguments[0])
98    instance.public = value
99    return value
100
101 def set_max_players_command(instance, player, arguments):
102   """ Set the maximum number of players allowed to join an instance.
103
104   Args:
105     instance: The GameInstance database model to change.
106     player: The player requesting the change. This player must be the
107       current leader of the instance.
108     arguments: A single item list containing the desired integer value
109       for the max players of this instance.
110
111   If the maximum player count is set to a value lower than the current
112   number of players, no players will be removed. However, new players
113   will not be able to join until the max players count goes up or
114   enough players leave the instance that the number of players is less
115   than the maximum.
116
117   Returns:
118     The new value of max_players for the instance.
119
120   Raises:
121     ValueError if the requesting player is not the leader of the
122       instance.
123     ValueError if the argument is unable to be parsed into an integer.
```

```
124     """
125     instance.check_leader(player)
126     max_players = int(arguments[0])
127     instance.max_players = max_players
128     return max_players
129
130   def get_public_instances_command(model, player, arguments = None):
131     """ Return a list of public instances of the specified game.
132
133     Args:
134       model: Either a Game or GameInstance database model. If model is a
135         GameInstance, this will return the public instances of its
136         parent Game.
137       player: Not used. Value can be anything.
138       arguments: Not used, can be any value.
139
140     Returns:
141       A list of all public instances in this game that have less players
142       than their maximum (i.e. can be joined). Instances are sorted with
143       the newest ones first. Each entry in the list of instances is
144       itself a three item list with the instance id as the first item,
145       the number of players currently in the game as the second item and
146       the maximum number of players (if any) as the third item. If no
147       maximum number of players is set for the game instance the third
148       item will be set to zero.
149     """
150     game = utils.get_game(model)
151     public_instances = game.get_public_instances_query().fetch(1000)
152     return [[i.key().name(), len(i.players), i.max_players]
153             for i in public_instances]
154
155   def delete_instance_command(instance, player, arguments = None):
156     """ Delete an instance and its messages.
157
158     Args:
159       instance: The instance to delete.
160       player: The player requesting the deletion. This player must
161         be the current leader of the instance.
162       arguments: Not used, can be any value.
163
164     Makes a good faith effort to delete the messages, but deleting large
165     numbers of database entries is currently very buggy in
166     AppEngine. This will hopefully get better over time as AppEngine
167     advances. See the method delete_messages in models/game_instance.py
168     for more information.
169
170     If the deletion of messages fails the exception will be logged and
171     this command will return normally.
172
173     Returns:
174       True if the instance deletes succesfully.
175
176     Raises:
177       ValueError if player is not the leader of the instance.
```

```
178       ValueError if instance is not a GameInstance model.
179     """
180     if instance.__class__.__name__ != 'GameInstance':
181       raise ValueError("Only models of type GameInstance may be deleted.
          ")
182
183     instance.check_leader(player)
184     try:
185       instance.delete_messages()
186     except apiproxy_errors.ApplicationError, err:
187       logging.debug("Exception during message deletion: %s" %
188                     traceback.format_exc())
189     db.delete(instance)
190     instance.do_not_put = True
191     return True
192
193   def decline_invite_command(instance, player, arguments = None):
194     """ Remove a player from the invited list of an instance.
195
196     Args:
197       instance: The instance to uninvite player from.
198       player: The player wishing to decline an invite.
199       arguments: Not used, can be any value.
200
201     If the player wasn't actually invited to the game, nothing happens
202     and this method returns false.
203
204     Returns:
205       True if the player was previously invited to the game, False
206       otherwise.
207     """
208     if player in instance.invited:
209       instance.invited.remove(player)
210       return True
211     return False
212
213   command_dict = {
214     'sys_email' : send_email_command,
215     'sys_set_public' : set_public_command,
216     'sys_set_max_players' : set_max_players_command,
217     'sys_get_public_instances' : get_public_instances_command,
218     'sys_delete_instance' : delete_instance_command,
219     'sys_decline_invite' : decline_invite_command,
220
221     # Scoreboard commands.
222     'scb_get_scoreboard' : scoreboard.get_scoreboard_command,
223     'scb_get_score' : scoreboard.get_score_command,
224     'scb_add_to_score' : scoreboard.add_to_score_command,
225     'scb_set_score' : scoreboard.set_score_command,
226     'scb_clear_scoreboard' : scoreboard.clear_scoreboard_command,
227
228     # Card commands.
229     'crd_set_deck' : card_game.set_deck_command,
230     'crd_deal_cards' : card_game.deal_cards_command,
```

```
231     'crd_draw_cards' : card_game.draw_cards_command,
232     'crd_discard' : card_game.discard_command,
233     'crd_pass_cards' : card_game.pass_cards_to_player_command,
234     'crd_cards_left' : card_game.get_cards_remaining_command
235     }
```

A.3: utils.py - Helper utility functions for input sanitizing and database operations.

```
1  # Copyright 2010 Google Inc.
2
3  # Licensed under the Apache License, Version 2.0 (the "License");
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10 # distributed under the License is distributed on an "AS IS" BASIS,
11 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
     implied.
12 # See the License for the specific language governing permissions and
13 # limitations under the License.
14 """
15 Utility functions for input validation and database model access.
16 """
17
18 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
19
20 import re
21 from google.appengine.ext import db
22 from google.appengine.ext.db import Key
23
24 EMAIL_ADDRESS_REGEX = ("([0-9a-zA-Z]+[-._+&amp;])*[0-9a-zA-Z]+@"
25                        "([-0-9a-zA-Z]+[.])+[a-zA-Z]{2,6}")
26
27 def get_game_model(gid):
28   """ Return a Game model for the given game id.
29
30   Args:
31     gid: The game id of the Game.
32
33   Returns:
34     The database model for the specified id or None if no such model
35     exists.
36   """
37   game_key = Key.from_path('Game', gid)
38   model = db.get(game_key)
39   return model
40
41 def get_instance_model(gid, iid):
42   """ Return a GameInstance model for the given game and instance ids.
43
44   Args:
```

```
45      gid: The game id of the GameInstance.
46      iid: The instance id of the GameInstance.
47
48    Returns:
49      The database model for the specified ids or None if the
50      GameInstance doesn't exist..
51    """
52    instance_key = Key.from_path('Game', gid, 'GameInstance', iid)
53    model = db.get(instance_key)
54    return model
55
56  def check_playerid(pid, instance = None):
57    """ Return a valid player id.
58
59    Args:
60      pid: A string containing the email address of the player or the
61        special identified 'leader'.
62      instance: (optional) The instance from which to fetch the leader
63        from when pid is 'leader'.
64
65    Returns:
66      Strips the supplied player id of superfluous characters and
67      returns only the email address. Also does conversion of the
68      special string 'leader' to the current leader of instance.
69
70    Raises:
71      ValueError if pid does not match an email address regular
72      expression.
73    """
74    if instance and pid.lower() == 'leader':
75      pid = instance.leader
76
77    if pid is None or pid == "":
78      raise ValueError('The player identifier is blank.')
79    stripped_email = re.search(EMAIL_ADDRESS_REGEX, pid)
80    if stripped_email is None:
81      raise ValueError('%s is not a valid email address.' % pid)
82    return stripped_email.group(0)
83
84  def check_gameid(gid):
85    """ Validate the game id to make sure it is not empty.
86
87    Args:
88      gid: The game id to check
89
90    Returns:
91      The game id.
92
93    Raises:
94      ValueError if the game id is the empty string or None.
95    """
96    if gid == "" or gid is None:
97      raise ValueError('Bad Game Id: %s' % gid)
98    return gid
```

```
99
100 def check_instanceid(iid):
101   """ Validate the instance id to make sure it is not empty.
102
103   Args:
104     iid: The instance id to check
105
106   Returns:
107     The instance id.
108
109   Raises:
110     ValueError if the instance id is the empty string or None.
111   """
112   if iid == "" or iid is None:
113     raise ValueError('No instance specified for request.')
114   return iid
115
116 def get_boolean(value):
117   """ Return a bool from value.
118
119   Args:
120     value: A string or bool representing a boolean.
121
122   Returns:
123     If value is a bool, value is returned without modification.
124
125     If value is a string this will convert 'true' and 'false'
126     (ignoring case) to their associated values.
127
128   Raises:
129     ValueError if value does not match one of the string tests and is
130     not a bool.
131   """
132   if type(value) is not bool:
133     value = value.lower()
134     if value == 'true':
135       value = True
136     elif value == 'false':
137       value = False
138     else:
139       raise ValueError("Boolean value was not valid")
140   return value
141
142 def get_game(model):
143   """ Return a Game object.
144
145   Args:
146     model: A database model that is either a GameInstance or Game.
147
148   Returns:
149     Either returns model or its parent if either of them is a Game
150     object.
151
152   Raises:
```

```
    ValueError if either model or its parent is not a Game object.
  """
  if model.__class__.__name__ == 'GameInstance':
    model = model.parent()
  if model.__class__.__name__ == 'Game':
    return model
  raise ValueError('Invalid model passed to get_game')
```

A.1.1 Models

A.4: game.py - The game database model.

```
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# WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
    implied.
# See the License for the specific language governing permissions and
# limitations under the License.
"""
The Game database model class and associated methods.
"""

__authors__ = ['"Bill Magnuson" <billmag@mit.edu>']

from google.appengine.ext import db
from game_instance import GameInstance

class Game(db.Model):
  """ A model for a game type.

  A Game is the parent object of GameInstance objects. Each Game
  object should correspond to a type of game. Class methods are
  available that provide queries to discover GameInstance objects
  with this parent.

  The key_name of a Game should be the game's name.

  Attributes:
    instance_count: The number of instances that have been made with
      this Game as their parent. This number is managed manually.
  """
  instance_count = db.IntegerProperty(default=0)

  def get_new_instance(self, prefix, player):
    """ Create a new GameInstance and return its model.
```

```
40
41      Args:
42        prefix: A string used as the beginning of the instance id.
43        player: The email address of the player.
44
45      When this returns, neither this Game model or the new
46      GameInstance have been put() in the database. If the GameInstance
47      should persist, both models need to be put().
48
49      Returns:
50        A GameInstance object with a unique instance id beginning with
51        prefix and player as the leader and sole member of the
52        instance.
53      """
54      prefix = prefix.replace(' ', '')
55      new_iid = prefix
56      self.instance_count += 1
57      new_index = self.instance_count
58      while GameInstance.get_by_key_name(new_iid, parent=self) is not
        None:
59        new_index += 1
60        new_iid = prefix + str(new_index)
61      instance = GameInstance(parent = self, key_name = new_iid,
62                              players = [player], leader = player)
63      return instance
64
65    def get_public_instances_query(self, keys_only = False):
66      """ Return a query object for public instances of this game.
67
68      Args:
69        keys_only (optional): Whether this database query should return
70          only keys, or entire models.
71
72      Returns:
73        A query object of all public game instances that are not full
74        in order of creation time from oldest to newest. Any instance
75        returned by this query should be able to be joined by any
76        player at the time the results are fetched.
77      """
78      query = GameInstance.all(keys_only = keys_only)
79      query.filter("public =", True)
80      query.filter("full =", False)
81      query.ancestor(self.key())
82      query.order('-date')
83      return query
84
85    def get_invited_instance_keys_query(self, player):
86      """ Return a query object for instances a player has been invited
        to.
87
88      Args:
89        player: The email address of the player.
90
91      Returns:
```

```
92        A query object of all game instances that player has been
93        invited to and that are not full in order of creation time from
94        oldest to newest. Any instance returned by this query should be
95        able to be joined by the player at the time the results are
96        fetched.
97      """
98      query = GameInstance.all(keys_only = True)
99      query.filter("invited =", player)
100     query.filter("full =", False)
101     query.ancestor(self.key())
102     query.order('-date')
103     return query
104
105   def get_joined_instance_keys_query(self, player):
106     """ Return a query object for instances a player has already
        joined.
107
108     Args:
109       player: The email address of the player.
110
111     Returns:
112       A query object of all game instances that player has joined in
113       order of creation time from oldest to newest.
114     """
115     query = GameInstance.all(keys_only = True)
116     query.filter("players =", player)
117     query.ancestor(self.key())
118     query.order('-date')
119     return query
```

A.5: game_instance.py - The game instance database model.

```
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8  # Unless required by applicable law or agreed to in writing, software
9  # distributed under the License is distributed on an "AS IS" BASIS,
10 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
       implied.
11 # See the License for the specific language governing permissions and
12 # limitations under the License.
13 """ The GameInstance database model class and associated methods."""
14
15 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
16
17 from datetime import datetime
18 from django.utils import simplejson
19 from game_server import utils
20 from google.appengine.ext import db
```

```
21 from message import Message
22
23 class GameInstance(db.Expando):
24   """ A model for an instance of a game.
25
26   A GameInstance contains all of the membership and message
27   information for an instance of a particular game. It is implemented
28   as an Expando model to allow extensions and custom modules to add
29   dynamic properties in order to extend the functionality of the
30   instance.
31
32   The key_name of a GameInstance should be the unique instance id.  A
33   GameInstance's parent is the Game model that it is an instance of.
34
35   Attributes:
36     players: A list of the email addresses of players currently in the
37       instance.
38     invited: A list of email addresses of invited players.
39     leader: The player that is currently the leader of the instance.
40     date: The date of creation, automatically set upon instantiation.
41     public: A bool that determines whether a player must first be
42       invited before they can join this instance.
43     full: A boolean indicating whether or not the game has reached
44       its maximum membership. Automatically set when the GameInstance
45       is put.
46     max_players: An integer for the maximum number of players allowed
47       in this instance or 0 if there is no maximum.
48
49   """
50   players = db.StringListProperty(required=True)
51   invited = db.StringListProperty(default=[])
52   leader = db.StringProperty(required=True)
53   date = db.DateTimeProperty(required=True, auto_now=True)
54   public = db.BooleanProperty(default=False)
55   full = db.BooleanProperty(default=False)
56   max_players = db.IntegerProperty(default=0)
57
58   def put(self):
59     """ Set the value of full and put this instance in the database.
       """
60     self.set_full()
61     db.Model.put(self)
62
63   def set_full(self):
64     """ Set the full attribute of this entity appropriately.
65
66     This should be called at put time to make sure that any stored
67     GameInstance model has the appropriate value for full. A game is
68     full if it has a non-zero value for max players which is less than
69     or equal to the number of players in the game.
70     """
71     if self.max_players == 0 or self.max_players > len(self.players):
72       self.full = False
73     else:
```

```
74        self.full = True
75
76    def to_dictionary(self):
77      """ Return a dictionary representation of the instance's
        attributes. """
78      return {'gameid' : self.parent().key().name(),
79              'instanceId' : self.key().name(),
80              'leader' : self.leader,
81              'players' : self.players,
82              'invited' : self.invited,
83              'public' : self.public,
84              'max_players' : self.max_players}
85
86    def __str__(self):
87      """ Return a json string of this model's dictionary. """
88      return simplejson.dumps(self.to_dictionary())
89
90    def create_message(self, sender, msg_type, recipient, content):
91      """ Create a new message model with this instance as its parent.
92
93        Args:
94          sender: A string describing the creator of the message.
95          msg_type: A string that acts as a key for the message.
96          recipient: The intended recipient of this message. The
97            recipient should either be the empty string or an email
98            address. Messages sent with the empty string as their
99            recipient can be fetched by any player.
100         content: A python list or dictionary representing the content
101           of this message. Converted to a json string for storage.
102
103       Returns:
104         A new Message model with the specified attributes. This model
105         has not yet been put in the database.
106       """
107       return Message(parent = self, sender = sender, msg_type = msg_type
        ,
108                      recipient = recipient, content = simplejson.dumps(
        content))
109
110   def get_messages(self, time = datetime.min, count = 1000,
111                    message_type='', recipient=''):
112     """ Return a list of message dictionaries using query_messages.
113
114       Args (optional):
115         time: (default: datetime.min) All messages retrieved must have
116           been created after this time..
117         count: (default 1000) The maximum number of messages to
118           retrieve.
119         message_type: (default '') The message type to retrieve. If
120           left as None or the empty string then all messages matching
121           other criteria will be returned.
122         recipient: (default '') The recipient of the messages to
123           retrieve.  All messages sent with a recipient of the empty
124           string will also be retrieved.
```

```
125
126       Returns:
127         The dictionary representation of all messages matching the
128         above criteria that were created with this instance as the
129         parent. The newest 'count' messages (that are newer than time)
130         are retrieved and then returned in order such that the first
131         message in the returned list is the oldest.
132
133         Note that the first message returned is not necessarily the
134         oldest one that is newer than time. This can occur if the
135         number of matching messages is greater than 'count' since the
136         'count' newest are selected before their order is reversed.
137       """
138       return [message.to_dictionary() for message in
139               self.get_messages_query(message_type, recipient,
140                                       time = time).fetch(count)[::-1]]
141
142     def get_messages_query(self, message_type, recipient,
143                            time = datetime.min, sender = None,
144                            keys_only = False):
145       """ Return a message query from this instance.
146
147       Args:
148         message_type: The message type to retrieve. If left as None or
149           the empty string then all messages matching other criteria
150           will be returned.
151         recipient: The recipient of the messages to retrieve. All
152           messages sent with a recipient of the empty string will also
153           be retrieved.
154         time: All messages retrieved must have been created after this
155           time.
156         sender: The sender of the message.
157         keys_only: If keys_only is set to true, this will only search
158           for messages that have recipient = recipient. Thus, it will
159           only include messages sent with no recipient if recipient
160           is set to ''.
161
162       Returns:
163         A query object that can be fetched or further modified.
164       """
165       query = Message.all(keys_only = keys_only)
166       query.ancestor(self.key())
167       query.filter('date >', time)
168       if message_type is not None and message_type != '':
169         query.filter('msg_type =', message_type)
170       if sender:
171         query.filter('sender =', sender)
172       # Avoid doing two queries when we don't need to.
173       if recipient == '':
174         query.filter('recipient =', '')
175       else:
176         if keys_only:
177           query.filter('recipient =', recipient)
178         else:
```

```
179           query.filter("recipient IN", [recipient, ''])
180       query.order('-date')
181       return query
182
183     def delete_messages(self, mtype = None):
184       """ Delete messages of a specified kind.
185
186       Args:
187         type: A string of the message type to delete.
188
189       Due to timeout issues with App Engine, this method will currently
190       only succeed when running on App Engine if the number of messages
191       being deleted is relatively small (~hundreds). It will attempt to
192       delete up to 1000. The timeout retry wrapper (see
193       game_server/autoretry_datastore.py) and using keys only search
194       drastically increases the chances of success, but this method is
195       still not guaranteed to complete.
196
197       For more information see:
198       http://groups.google.com/group/google-appengine/
199         browse_thread/thread/ec0800a3ca92fe69?pli=1
200       http://stackoverflow.com/questions/108822/
201         delete-all-data-for-a-kind-in-google-app-engine
202       """
203       if mtype:
204         db.delete(Message.all(keys_only = True).filter('msg_type =',
        mtype)
205                   .ancestor(self.key()).order('date').fetch(1000))
206       db.delete(Message.all(keys_only = True).ancestor(self.key()).order
        ('date')
207                 .fetch(1000))
208
209     def check_player(self, pid):
210       """ Confirm that a player is currently in the instance.
211
212       Args:
213         pid: A string containing the player's email address.
214
215       Returns:
216         The email address of the player.
217
218       Raises:
219         ValueError if the player is not in this instance.
220       """
221       player = utils.check_playerid(pid)
222       if player in self.players:
223         return player
224       raise ValueError("%s is not in instance %s" % (pid, self.key().
        name()))
225
226     def check_leader(self, pid):
227       """ Confirm that a player is the leader of the instance.
228
229       Args:
```

```
      pid: A string containing the player's email address.

    Returns:
      The email address of the leader if pid contains it.

    Raises:
      ValueError if the player is not the leader of this instance.
    """
    player = utils.check_playerid(pid)
    if player == self.leader:
      return player
    raise ValueError("You must be the leader to perform this operation
    .")

  def add_player(self, player):
    """ Add a new player to this instance.

    Args:
      player: The email address of the player to add.

    A player can join a game instance if it is not full and either the
    instance is public or the player has been invited.  If the player
    is already in the game instance this will succeed without
    modifying the instance.

    Raises:
      ValueError if the player is not already in the game and is
      unable to join.
    """
    if player not in self.players:
      if player not in self.invited and not self.public:
        raise ValueError("%s not invited to instance %s."
                         % (player, self.key().name()))
      if self.full:
        raise ValueError("%s could not join: instance %s is full"
                         % (player, self.key().name()))
      if player in self.invited:
        self.invited.remove(player)
      self.players.append(player)
      self.set_full()
```

A.6: message.py - The message database model.

```
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```

```
10 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
     implied.
11 # See the License for the specific language governing permissions and
12 # limitations under the License.
13 """ The Message database model class and associated methods."""
14
15 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
16
17 from datetime import datetime
18 from django.utils import simplejson
19 from game_server import iso8601
20 from google.appengine.ext import db
21
22 class Message(db.Expando):
23   """ A model for a message sent to a player in a game instance.
24
25   Messages are used to pass information from player to player and from
26   server to player. A Message's parent is the GameInstance which it is
27   created for.
28
29   Attributes:
30     msg_type: A string that acts as a key for the message.
31     recipient (optional): The intended recipient of this message.
32     content: JSON string that represents the contents of the message.
33     date: The date of creation, automatically set upon instantiation.
34     sender: A string describing the creator of the message.
35   """
36   msg_type = db.StringProperty(required=True)
37   recipient = db.StringProperty(required=False)
38   content = db.TextProperty(required=False)
39   date = db.DateTimeProperty(required=True, auto_now_add=True)
40   sender = db.StringProperty(required=True)
41
42   def to_dictionary(self):
43     """ Return a Python dictionary of the message.
44
45     Returns a dictionary of the message:
46       type: msg_type
47       mrec: recipient
48       contents: the Python representation of the content JSON string.
49       mtime: The iso8601 string representation of the creation time of
50         the message.
51       msender: sender
52     """
53     return {'type' : self.msg_type, 'mrec' : self.recipient,
54             'contents' : simplejson.loads(self.content),
55             'mtime' : self.date.isoformat(),
56             'msender' : self.sender}
57
58   def to_json(self):
59     """ Return a json representation of the dictionary of this message
       """
60     return simplejson.dumps(self.to_dictionary())
61
```

```
62    def get_content(self):
63      """ Return the Python representation of the contents of this
        message. """
64      return simplejson.loads(self.content)
```

A.1.2 Extensions

A.7: card_game.py - A library for handling card games in a game instance.

```
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7
8  # Unless required by applicable law or agreed to in writing, software
9  # distributed under the License is distributed on an "AS IS" BASIS,
10 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
       implied.
11 # See the License for the specific language governing permissions and
12 # limitations under the License.
13 """
14 Functionality for card games. Uses a single deck of cards for and
15 keeps track of each players hands using a dictionary stored with the
16 game instance.
17
18 The default deck is a standard 52 card deck. Each card is represented
19 as a two element list with its numerical value (1-13) as the first
20 element and its suit as the second element. Suits are the strings
21 'Hearts', 'Spades', 'Clubs' and 'Diamonds'.
22 """
23
24 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
25
26 import random
27 from django.utils import simplejson
28 from game_server.models.message import Message
29 from game_server.utils import get_boolean
30 from google.appengine.ext import db
31
32 default_deck = [[n, s] for n in range(14)[1:]
33                 for s in  ['Hearts','Spades', 'Clubs','Diamonds']]
34
35 ############################
36 # Server command functions #
37 ############################
38
39 def set_deck_command(instance, player, arguments):
40   """ Set the instance's deck to a new list of cards.
41
42   Args:
```

```
43      instance: The GameInstance database model for this operation.
44      player: The email address of the player requesting the action.
45        For this command, the player must be the current leader of the
46        instance.
47      arguments: A list of the cards to set the deck to.
48
49    Resets the deck used by card games from a standard 52 card deck to
50    the deck specified by the arguments list. A new deck can only be set
51    when no other card game methods have been invoked for a particular
52    game instance. The deck will remain the same throughout the life of
53    the game instance.
54
55    Returns:
56      The number of cards in the new deck.
57
58    Raises:
59      A ValueError if the requesting player is not the leader of the
60      instance.
61    """
62    instance.check_leader(player)
63    return set_deck(instance, arguments)
64
65  def deal_cards_command(instance, player, arguments):
66    """ Deal cards to players.
67
68    Args:
69      instance: The GameInstance database model for this operation.
70      player: The email address of the player requesting the action.
71        The player must be the current leader of the instance.
72      arguments: A list of arguments to this command as explained below.
73
74    The arguments list for this command consists of five items in order:
75      1: cards_to_deal - The number of cards to deal as an integer.
76      2: shuffle_deck - A boolean controlling whether or not the deck
77         should be shuffled before the new hands are dealt. If the deck
78         is shuffled, all hands are also cleared regardless of the value
79         of is_new_hand.
80      3: is_new_hand - A boolean indicating whether this is a new hand
81         or not.  If it is a new hand, then all hands will be cleared
82         before the new cards are dealt. If the deck is shuffled before
83         the cards are dealt then the hands are cleared automatically
84         and this has no effect.
85      4: ignore_empty_deck - Another boolean controlling whether to
86         ignore an empty deck or not. If it is true, then cards will be
87         dealt until the deck runs out and then this command will return
88         successfully. If it is false, an error will occur if the deck
89         runs out of cards.
90      5: A list of player id's to be dealt to in the order to deal to
91         them. Cards will be dealt one at a time to players in the order
92         that they appear in this list.
93
94    Cards are dealt to players using the instance's deck according to
95    the arguments specified above. The cards are dealt in the order
96    determined by the last shuffling. Until a deck is re-shuffled, cards
```

```
    will be dealt as if they were removed from the top of the deck and
    given to the player permanently.

    Returns:
      The hand of the requesting player after cards are dealt.

    Raises:
      An IndexError if the deck runs out of cards and empty deck errors
      are not being ignored.
      A ValueError if any of the player id's in the list of players to
      deal to are not in the game instance.
      A ValueError if the requesting player is not the leader of the
      instance.
    """
    instance.check_leader(player)
    cards_to_deal = int(arguments[0])
    shuffle = get_boolean(arguments[1])
    if shuffle:
      shuffle_deck(instance)
    is_new_hand = get_boolean(arguments[2])
    ignore_empty_deck = get_boolean(arguments[3])
    hands = deal_cards(instance, cards_to_deal, is_new_hand,
     ignore_empty_deck,
                       arguments[4])
    return hands[player]

def draw_cards_command(instance, player, arguments):
    """ Draw cards from the deck and put them into the calling player's
     hand.

    Args:
      instance: The GameInstance database model for this operation.
      player: The email address of the player requesting the action.
      arguments: A list of arguments to this command as explained below.

    The arguments list for this command consists of two items in order:
      1: cards_to_draw - The number of cards to attempt to draw.
      2: ignore_empty_deck - A boolean controlling whether to ignore an
         empty deck or not. If it is true, cards can be drawn until the
         deck runs out and then this command will return
         successfully. If it is false, an error will occur if the deck
         runs out of cards and no changes will be made to the hand of
         the player.

    Returns:
      The hand of the player after drawing the new cards.

    Raises:
      An IndexError if the deck runs out of cards and empty deck errors
      are not being ignored.
      ValueError if the requesting player is not in the instance.
    """
    cards_to_draw = int(arguments[0])
    ignore_empty_deck = get_boolean(arguments[1])
```

```
149     return draw_cards(instance, player, cards_to_draw, ignore_empty_deck
        )
150
151   def discard_command(instance, player, arguments):
152     """ Remove the specified cards from the calling player's hand.
153
154     Args:
155       instance: The GameInstance database model for this operation.
156       player: The email address of the player requesting the action.
157       arguments: A list of cards to discard.
158
159     Discarded cards are removed from a player's hand permanently. They
160     are not re-added to the deck of cards to be dealt to other
161     players. However, once a deck is shuffled, all cards become
162     available again including any that have been discarded.
163
164     If a player tries to discard a card that is not in their hand on the
165     server, the request to discard that particular card is ignored, but
166     the execution of the command continues.
167
168     Returns:
169       The current hand of the requesting player.
170     """
171     return discard(instance, player, arguments)
172
173   def pass_cards_to_player_command(instance, player, arguments):
174     """ Remove cards from the calling player's hand and add them to
          another hand.
175
176     Args:
177       instance: The GameInstance database model for this operation.
178       player: The email address of the player requesting the action.
179       arguments: A list of two items. The first item is the email
180         address of the player to pass the cards to and the second is a
181         list of cards to pass to them.
182
183     Raises:
184       A ValueError if the player to pass the cards to is not in the game
185       instance.
186
187     """
188     hands = get_hand_dictionary(instance)
189     to_player = instance.check_player(arguments[0])
190     return pass_cards(instance, player, to_player, arguments[1])
191
192   def get_cards_remaining_command(instance, player, arguments = None):
193     """ Return the number of cards left in this deck to deal.
194
195     Args:
196       instance: The GameInstance database model for this operation.
197       player: The email address of the player requesting the action.
198       arguments: Not used, can be any value.
199
200     Returns:
```

```
201       The number of cards that can still be dealt before the deck is
202       empty.  If the deck has not been set or no cards have been dealt
203       (in the case that the default deck is being used), returns -1.
204     """
205     return cards_left(instance)
206
207   ###########
208   # Helpers #
209   ###########
210
211   def get_deck(instance):
212     """ Return the deck for this instance.
213
214     Args:
215       instance: The GameInstance database model for this operation.
216
217     Returns:
218       The current deck for this instance. If no deck exists, returns the
219       default deck, unshuffled.
220     """
221     if 'crd_deck_index' not in instance.dynamic_properties():
222       instance.crd_deck_index = 0
223     if 'crd_deck' not in instance.dynamic_properties():
224       instance.crd_deck = [simplejson.dumps(card) for card in
        default_deck]
225     return instance.crd_deck
226
227   def set_deck(instance, deck):
228     """ Set the deck for this instance to a new one.
229
230     Args:
231       instance: The GameInstance database model for this operation.
232       deck: A list of cards to set as a new deck.
233
234     Returns:
235       The number of cards in the new deck.
236
237     Raises:
238       AttributeError if a deck has already been created for this
239       instance.
240     """
241     if 'crd_deck' in instance.dynamic_properties():
242       raise AttributeError('Deck can only be set as the first operation
        in '
243                            'a card game.')
244     instance.crd_deck =[simplejson.dumps(card) for card in deck]
245     instance.crd_deck_index = 0
246     return len(instance.crd_deck)
247
248   def get_hand_dictionary(instance):
249     """ Return a dictionary with the hands of each player in the
        instance.
250
251     Args:
```

```
252       instance: The GameInstance database model for this operation.
253
254     Returns:
255       A dictionary with a list for each player in the game. Each
256       player's list will include the cards currently in their hand. Keys
257       in the dictionary are the email addresses of players.
258     """
259     if 'crd_hands' not in instance.dynamic_properties():
260       return get_empty_hand_dictionary(instance)
261     else:
262       return simplejson.loads(instance.crd_hands)
263
264   def get_empty_hand_dictionary(instance):
265     """ Return a dictionary with an empty hand for each player in the
        instance.
266
267     Args:
268       instance: The GameInstance database model for this operation.
269
270     Returns:
271       A dictionary with an empty list for each player in the game. Keys
272       in the dictionary are the email addresses of players.
273     """
274     hands = {}
275     for player in instance.players:
276       hands[player] = []
277     return hands
278
279   def set_hand_dictionary(instance, hands, send_messages = True):
280     """ Set the hands of all players and send new hand messages.
281
282     Args:
283       instance: The GameInstance database model for this operation.
284       hands: A dictionary containing the hand of each player in the
285       game.
286       send_messages: Whether or not to send a message to each player
287         with their new hand.
288
289     Stores the hands dictionary in the game instance. If send_messages
290     is True, this will also send a new 'crd_hand' message to each player
291     with their new hand.
292     """
293     if send_messages:
294       message_list = []
295       for player in instance.players:
296         message_list.append(instance.create_message(player, 'crd_hand',
297                                                     player, hands[player
        ]))
298       db.put(message_list)
299     instance.crd_hands = db.Text(simplejson.dumps(hands))
300
301   def get_player_hand(instance, player):
302     """ Get the hand of a single player in an instance.
303
```

```
304     Args:
305       instance: The GameInstance database model for this operation.
306       player: The email address of the player.
307
308     Returns:
309       The list of cards that the player has or an empty list if they
310       do not have a hand.
311
312     Raises:
313       ValueError if the player is not in the instance.
314     """
315     player = instance.check_player(player)
316     hands = get_hand_dictionary(instance)
317     return hands.get(player, [])
318
319   def set_player_hand(instance, player, hand, send_message = True):
320     """ Set the hand of a single player in an instance.
321
322     Args:
323       instance: The GameInstance database model for this operation.
324       player: The email address of the player.
325       hand: The new hand of the player.
326       send_message: Whether to send player a 'crd_hand' message
327         with their new hand.
328
329     Stores the new hands dictionary with the updated hand for player.
330     If send_message is True, a message will be sent to player with
331     their new hand.
332
333     Raises:
334       ValueError if the player is not in the instance.
335     """
336     player = instance.check_player(player)
337     hands = get_hand_dictionary(instance)
338     hands[player] = hand
339     set_hand_dictionary(instance, hands, send_messages = False)
340     if send_message:
341       instance.create_message(player, 'crd_hand', player, hand).put()
342
343   def get_next_card(instance):
344     """ Return the card in the deck.
345
346     Args:
347       instance: The GameInstance database model for this operation.
348
349     Returns:
350       The Python representation of the next card in the deck. Because
351       cards are stored as JSON strings they are first decoded before
352       being returned.
353
354     Raises:
355       ValueError if the JSON decoding fails.
356       IndexError if the deck has run out of cards.
357     """
```

```
358
359   if cards_left(instance) == 0:
360     raise IndexError('Deck is empty')
361   card = simplejson.loads(get_deck(instance)[instance.crd_deck_index])
362   instance.crd_deck_index = instance.crd_deck_index + 1
363   return card
364
365 def shuffle_deck(instance):
366   """ Shuffle the deck and reset all hands.
367
368   Args:
369     instance: The GameInstance database model for this operation.
370
371   Shuffles all cards in the original deck and makes them available to
372   be dealt or drawn again. Also clears all players hands.
373
374   Returns:
375     The number of cards in the deck.
376   """
377   deck = get_deck(instance)
378   random.shuffle(deck)
379   instance.crd_deck_index = 0
380   instance.crd_deck = deck
381
382   set_hand_dictionary(instance, get_empty_hand_dictionary(instance))
383   return len(instance.crd_deck)
384
385 def pass_cards(instance, from_player, to_player, cards):
386   """ Pass cards from one player to another.
387
388   Args:
389     instance: The GameInstance database model for this operation.
390     from_player: Email address of the player who is passing the cards.
391     to_player: Email address of the player who is receiving the cards.
392     cards: A list of cards to pass.
393
394   Searches the hand of from_player for each card in cards and if it
395   is present, transfers it to_player's hand. If a card is not present,
396   it is ignored.
397
398   Returns:
399     The hand of from_player after passing the cards.
400   """
401   hands = get_hand_dictionary(instance)
402   from_player = instance.check_player(from_player)
403   to_player = instance.check_player(to_player)
404
405   for card in cards:
406     try:
407       hands[from_player].remove(card)
408       hands[to_player].append(card)
409     except ValueError:
410       pass
411   set_hand_dictionary(instance, hands)
```

```
412     return hands[from_player]
413
414 def discard(instance, player, cards, send_message = True):
415     """ Remove the specified cards from player's hand.
416
417     Args:
418       instance: The GameInstance database model for this operation.
419       player: The email address of the player to discard cards from.
420       cards: The cards to be discarded.
421       send_message: Whether to send player a 'crd_hand' message
422         with their new hand.
423
424     Discarded cards are removed from a player's hand permanently. They
425     are not re-added to the deck of cards to be dealt to other
426     players. However, once a deck is shuffled, all cards become
427     available again including any that have been discarded.
428
429     If a player tries to discard a card that is not in their hand on the
430     server, the request to discard that particular card is ignored, but
431     the execution of the command continues.
432
433     Returns:
434       The hand of player after discarding the cards.
435
436     Raises:
437       ValueError if the player is not in the instance.
438     """
439     hand = get_player_hand(instance, player)
440     for card in cards:
441       try:
442         hand.remove(card)
443       except ValueError:
444         pass
445     set_player_hand(instance, player, hand, send_message)
446     return hand
447
448 def deal_cards(instance, cards_to_deal, is_new_hand, ignore_empty_deck
      ,
449                deal_to):
450     """ Deal cards to players.
451
452     Args:
453       instance: The GameInstance database model for this operation.
454
455       cards_to_deal: The number of cards to deal as an integer.
456       is_new_hand: A boolean indicating whether this is a new hand or
457         not.  If it is a new hand, then all hands will be cleared before
458         the new cards are dealt. If the deck is shuffled before the
459         cards are dealt then the hands are cleared automatically and
460         this has no effect.
461       ignore_empty_deck: Another boolean controlling whether to ignore
462         an empty deck or not. If it is true, then cards will be dealt
463         until the deck runs out and then this command will return
464         successfully. If it is false, an error will occur if the deck
```

```
465         runs out of cards.
466       deal_to: A list of player id's to be dealt to in the order to deal
467         to them.  Cards will be dealt one at a time to players in the
468         order that they appear in this list.
469
470     The cards are dealt in the order determined by the last
471     shuffling. Until a deck is re-shuffled, cards will be dealt as if
472     they were removed from the top of the deck and given to the player
473     permanently.
474
475     Returns:
476       The hand of the requesting player after cards are dealt.
477
478     Raises:
479       ValueError if a player in deal_to is not in the instance.
480       IndexError if the deck runs out of cards and ignore_empty_deck is
481       not True.
482     """
483     hands = {}
484     if not is_new_hand:
485       hands = get_hand_dictionary(instance)
486
487     if cards_to_deal:
488       deal_to = [instance.check_player(pid) for pid in deal_to]
489       for player in deal_to:
490         hands.setdefault(player, [])
491       try:
492         for i in xrange(cards_to_deal):
493           for player in deal_to:
494             hands[player].append(get_next_card(instance))
495       except IndexError:
496         if not ignore_empty_deck:
497           raise
498
499     set_hand_dictionary(instance, hands)
500     return hands
501
502 def draw_cards(instance, player, cards_to_draw,
503                ignore_empty_deck = True, send_message = True):
504     """ Draw cards from the deck and put them into player's hand.
505
506     Args:
507       instance: The GameInstance database model for this operation.
508       player: The email address of the player to give the cards to.
509       cards_to_draw: The number of cards to draw from the deck.
510       ignore_empty_deck - A boolean controlling whether to ignore an
511         empty deck or not. If it is true, cards can be drawn until the
512         deck runs out and then this command will return
513         successfully. If it is false, an error will occur if the deck
514         runs out of cards and no changes will be made to the hand of
515         the player.
516       send_message: Whether to send player a 'crd_hand' message
517         with their new hand.
518
```

```
519     Returns:
520       The hand of the requesting player after they have drawn their
521       cards.
522
523     Raises:
524       ValueError if player is not in the game instance.
525       IndexError if the deck runs out of cards and ignore_empty_deck is
526       not True.
527     """
528     hand = get_player_hand(instance, player)
529     try:
530       for i in xrange(cards_to_draw):
531         hand.append(get_next_card(instance))
532     except IndexError:
533       if not ignore_empty_deck:
534         raise
535     set_player_hand(instance, player, hand, send_message)
536     return hand
537
538 def cards_left(instance):
539     """ Return the number of cards left to deal before a shuffle is
        required.
540
541     Args:
542       instance: The GameInstance database model for this operation.
543
544     Returns
545       The number of cards that can still be dealt before the deck is
546       empty. If the deck has not been set or no cards have been dealt
547       (in the case that the default deck is being used), returns -1.
548     """
549     if 'crd_deck' not in instance.dynamic_properties():
550       return -1
551     return len(instance.crd_deck) - instance.crd_deck_index
```

A.8: scoreboard.py - A library for keeping track of a per instance scoreboard.

```
1  # Copyright 2010 Google Inc.
2  # Licensed under the Apache License, Version 2.0 (the "License");
3  # you may not use this file except in compliance with the License.
4  # You may obtain a copy of the License at
5
6  #      http://www.apache.org/licenses/LICENSE-2.0
7
8  # Unless required by applicable law or agreed to in writing, software
9  # distributed under the License is distributed on an "AS IS" BASIS,
10 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
     implied.
11 # See the License for the specific language governing permissions and
12 # limitations under the License.
13 """
14 Provides methods to use a scoreboard with GameInstance models.
15
```

```
16 All scores are stored as integers with the convention that higher
17 numbers are better.
18 """
19
20 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
21
22 import operator
23 from django.utils import simplejson
24 from google.appengine.ext import db
25
26 ############################
27 # Server command functions #
28 ############################
29
30 def get_scoreboard_command(instance, player, arguments = None):
31   """ Get the current scoreboard.
32
33   Args:
34     instance: The GameInstance database model for this operation.
35     player: The email address of the player requesting this action.
36     arguments: Not used, can be any value.
37
38   Returns:
39     The complete scoreboard as a list of [score, email] lists for
40     each player in the game. The scoreboard is sorted with the highest
41     score first.
42   """
43   return format_scoreboard_for_app_inventor(get_scoreboard(instance))
44
45 def get_score_command(instance, player, arguments):
46   """ Set the score of a single player.
47
48   Args:
49     instance: The GameInstance database model for this operation.
50     player: The email address of the player requesting this action.
51     arguments: A one item list containing the player id of the
52       player to get the score of.
53
54   Returns:
55     The score of the requested player.
56
57   Raises:
58     ValueError if the player in arguments is not in the game.
59   """
60   get_score_player = instance.check_player(arguments[0])
61   return get_score(instance, get_score_player)
62
63 def set_score_command(instance, player, arguments):
64   """ Set a player's score to a new value.
65
66   Args:
67     instance: The GameInstance database model for this operation.
68     player: The email address of the player to set the score of.
69     arguments: A list of two items. The first item is the player id
```

```
70        of the player who's score is to be set. The second item is the
71        integer to set that player's score to.
72
73    Returns:
74      The complete scoreboard after setting the new score value.
75
76    Raises:
77      ValueError if the specified player is not in the instance.
78    """
79    player = instance.check_player(arguments[0])
80    new_score = arguments[1]
81    board = set_score(instance, player, new_score)
82    return format_scoreboard_for_app_inventor(board)
83
84
85  def add_to_score_command(instance, player, arguments):
86    """ Change a player's score by an integer amount.
87
88    Args:
89      instance: The GameInstance database model for this operation.
90      player: The email address of the player to add points to.
91      arguments: A list of two items. The first item is the player id
92        of the player who's score is to be set. The second item is the
93        integer amount to change that player's score by. This value can
94        be positive or negative.
95
96    In order for this operation to work correctly scores must be
97    represented in the scoreboard as single integer items.
98
99    Returns:
100     The complete scoreboard after adding to player's score.
101
102   Raises:
103     ValueError if the specified player is not in the instance.
104     ValueError if the specified score cannot parse correctly.
105   """
106   player = instance.check_player(arguments[0])
107   delta = int(arguments[1])
108   board = add_to_score(instance, player, delta)
109   return format_scoreboard_for_app_inventor(board)
110
111 def clear_scoreboard_command(instance, player, arguments = None):
112   """ Reset all scores to 0.
113
114   Args:
115     instance: The GameInstance database model for this operation.
116     player: The email address of the player requesting this action.
117       For this command, the player must be the current leader of the
118       instance.
119     arguments: Not used, can be any value.
120
121   Returns:
122     An empty scoreboard with a score of 0 for each player.
123
```

```
124     Raises:
125       ValueError if player is not the leader of this instance.
126     """
127     instance.check_leader(player)
128     instance.scoreboard = '{}'
129     return get_scoreboard_command(instance, player, arguments)
130
131
132   ###########
133   # Helpers #
134   ###########
135
136   def get_score(instance, player):
137     """ Get a player's score.
138
139     Args:
140       instance: The instance to get the scoreboard from.
141       player: The player to check the score of.
142
143     Returns:
144       The players score.
145
146     Raises:
147       ValueError if the player is not in the instance.
148     """
149     player = instance.check_player(player)
150     board = get_scoreboard(instance)
151     return board[player]
152
153   def set_score(instance, player, new_score):
154     """ Set a player's score.
155
156     Args:
157       instance: The game instance to modify the scoreboard of.
158       player: The player to set the score of.
159       new_score: An integer to set their score to.
160
161     Returns:
162       The scoreboard as a dictionary after setting a new value for
163       player's score.
164
165     Raises:
166       ValueError if the player is not in the instance.
167     """
168     player = instance.check_player(player)
169     scoreboard = get_scoreboard(instance)
170     scoreboard[player] = new_score
171     instance.scoreboard = simplejson.dumps(scoreboard)
172     return scoreboard
173
174   def add_to_score(instance, player, delta):
175     """ Change a player's score by delta.
176
177     Args:
```

```
178       instance: The game instance to modify the scoreboard of.
179       player: The player to change the score of.
180       delta: The integer amount to change player's score by (can be
181       negative).
182
183       In order for this operation to work correctly scores must be
184       represented in the scoreboard as single integer items.
185
186     Returns:
187       The scoreboard as a dictionary after modifying player's score.
188     """
189     player = instance.check_player(player)
190     scoreboard = get_scoreboard(instance)
191     if player in scoreboard:
192       scoreboard[player] += delta
193     else:
194       scoreboard[player] = delta
195     instance.scoreboard = db.Text(simplejson.dumps(scoreboard))
196     return scoreboard
197
198   def get_scoreboard(instance):
199     """ Get a dictionary of the scoreboard for the specified instance.
200
201     Args:
202       instance: The instance to get the scoreboard from.
203
204     Returns:
205       A dictionary with a score entry for each player in the
206       instance. If no score was previously present, a value of
207       0 is entered.
208     """
209     board = None
210     if 'scoreboard' not in instance.dynamic_properties():
211       board = {}
212     else:
213       board = simplejson.loads(instance.scoreboard)
214     for player in instance.players:
215       if not board.has_key(player):
216         board[player] = 0
217     return board
218
219   def format_scoreboard_for_app_inventor(board):
220     """ Return a scoreboard suitable to return to App Inventor.
221
222     Args:
223       board: The dictionary of scores for all players in the game.
224
225     Returns:
226       A list of [score, player email] lists ordered by highest score.
227     """
228     board_list = [[v,k] for k, v in board.items()]
229     board_list.sort(key = operator.itemgetter(0), reverse = True)
230     return board_list
```

A.2 Custom Modules

A.9: commands.py - The command dictionary for custom modules.

```
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# distributed under the License is distributed on an "AS IS" BASIS,
# WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
    implied.
# See the License for the specific language governing permissions and
# limitations under the License.
"""
Defines the commands available from custom modules. Custom modules
differ from built in server commands or server extensions because they
are more narrowly focused on a particular game's functionality.

Custom modules will generally be built on a per game basis and
included when game creators deploy their own App Engine servers.

This file currently includes commands for custom modules meant to be
used as examples. These can be removed to decrease load time if they
are not being used.
"""

__authors__ = ['"Bill Magnuson" <billmag@mit.edu>']

from custom_modules.androids_to_androids import ata_commands
from custom_modules.bulls_and_cows import bac_commands
from custom_modules.amazon import amazon_commands
from custom_modules.voting import voting_commands

custom_command_dict = {
    # Androids to Androids
    'ata_new_game' : ata_commands.new_game_command,
    'ata_submit_card' : ata_commands.submit_card_command,
    'ata_end_turn' : ata_commands.end_turn_command,

    # Bulls and Cows
    'bac_new_game' : bac_commands.new_game_command,
    'bac_guess' : bac_commands.guess_command,

    # Amazon
    'amz_keyword_search' : amazon_commands.keyword_search_command,
    'amz_isbn_search' : amazon_commands.isbn_search_command,

    # Voting
    'vot_cast_vote' : voting_commands.cast_vote_command,
```

```
49      'vot_get_results' : voting_commands.get_results_command,
50      'vot_new_poll' : voting_commands.make_new_poll_command,
51      'vot_close_poll' : voting_commands.close_poll_command,
52      'vot_delete_poll' : voting_commands.delete_poll_command,
53      'vot_get_poll_info' : voting_commands.get_poll_info_command,
54      'vot_get_my_polls' : voting_commands.get_my_polls_command
55      }
```

A.2.1 Amazon

A.10: amazon_commands.py - Amazon server commands.

```
1  # Copyright 2010 Google Inc.
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3  # you may not use this file except in compliance with the License.
4  # You may obtain a copy of the License at
5
6  #      http://www.apache.org/licenses/LICENSE-2.0
7
8  # Unless required by applicable law or agreed to in writing, software
9  # distributed under the License is distributed on an "AS IS" BASIS,
10 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
       implied.
11 # See the License for the specific language governing permissions and
12 # limitations under the License.
13 """ Looks up books on Amazon by keyword or ISBN
14
15 Uses a library originally downloaded from
16 http://blog.umlungu.co.uk/blog/2009/jul/12/pyaws-adding-request-
       authentication/
17 to access AWS E-Commerce Service API's and retrieve book results
18 for searches by keyword and ISBN number.
19 """
20
21 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>',
22                '"Dave Wolber" <wolber@usfca.edu>']
23
24
25 # This file has had its license and secret keys removed and will not
       function.
26 license_key = ''
27 secret_key = ''
28
29 from pyaws import ecs
30
31 return_limit = 5
32
33 def keyword_search_command(model, player, arguments):
34   """ Return books by keyword.
35
36   Args:
37     model: Not used, can be anything.
```

```
38      player: Not used, can be anything.
39      arguments: A one item list containing the keywords to search for.
40
41    Returns:
42      A list of three item lists. Each sublist represents
43      a result and includes the book title, its lowest found
44      price and its ASIN number.
45    """
46    return amazon_by_keyword(arguments[0])
47
48  def isbn_search_command(model, player, arguments):
49    """ Return a book result by ISBN number.
50
51    Args:
52      model: Not used, can be anything.
53      player: Not used, can be anything.
54      arguments: A one item list containing the keywords to search for.
55
56    Returns:
57      A list with a single sublist representing the book found.
58      The sublist contains the book title, its lowest found
59      price and its ASIN number.
60
61    Raises:
62      ValueError if the ISBN number is invalid.
63    """
64    return amazon_by_isbn(arguments[0])
65
66  def amazon_by_keyword(keyword):
67    """ Use the ecs library to search for books by keyword.
68
69    Args:
70      keyword: A string of keyword(s) to search for.
71
72    Returns:
73      A list of three item lists. Each sublist represents
74      a result and includes the book title, its lowest found
75      price and its ASIN number.
76    """
77    ecs.setLicenseKey(license_key)
78    ecs.setSecretKey(secret_key)
79    ecs.setLocale('us')
80
81    books = ecs.ItemSearch(keyword, SearchIndex='Books', ResponseGroup='
       Medium')
82    return format_output(books)
83
84  def amazon_by_isbn(isbn):
85    """ Use the ecs library to search for books by ISBN number.
86
87    Args:
88      isbn: The 10 digit ISBN number to look up.
89
90    Returns:
```

```
    A list with a single sublist representing the book found.
    The sublist contains the book title, its lowest found
    price and its ASIN number.

  Raises:
    ValueError if the ISBN number is invalid.
  """
  ecs.setLicenseKey(license_key)
  ecs.setSecretKey(secret_key)
  ecs.setLocale('us')
  try:
    books = ecs.ItemLookup(isbn, IdType='ISBN', SearchIndex='Books',
                           ResponseGroup='Medium')
    return format_output(books)
  except ecs.InvalidParameterValue:
    raise ValueError('Invalid ISBN')

def format_output(books):
  """ Return a formatted output list from an iterator returned by ecs.

  Args:
    books: An iterator of book results from the ecs library.

  Returns:
    A list of three item lists. Each sublist represents
    a result and includes the book title, its lowest found
    price and its ASIN number.
  """
  size = min(len(books), return_limit)
  return [[books[i].Title, get_amount(books[i]), books[i].ASIN]
          for i in xrange(size)]

def get_amount(book):
  """ Return the lowest price found or 'Not found.' if none exists.
    """
  try:
    if book.OfferSummary and book.OfferSummary.LowestNewPrice:
      return book.OfferSummary.LowestNewPrice.FormattedPrice
  except:
    return 'Not found.'
```

A.2.2 Androids to Androids

A.11: ata_commands.py - Androids to Androids game commands.

```
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```

```
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9  # distributed under the License is distributed on an "AS IS" BASIS,
10 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
       implied.
11 # See the License for the specific language governing permissions and
12 # limitations under the License.
13 """
14 A set of server commands to implement Androids to Androids.
15
16 Androids to Androids is a card game played by at least three
17 players. The first leader of the game is the creator of the game
18 instance. The game proceeds in rounds with the winner of each round
19 becoming the leader of the next round. To start the game, each player
20 is dealt seven cards with nouns on them. These cards comprise their
21 hand.
22
23 At the beginning of each round, an adjective or characteristic is
24 chosen at random and sent to each player. Every player except the
25 leader will then choose a card from their hand to submit for the
26 round. Upon submission their hand will be replenished with another
27 card so that they always have seven cards in their hand.
28
29 The leader will then choose a single noun card from those submitted by
30 the other players in response to the characteristic.  The leader can
31 use any criteria they wish to select the card that should win the
32 round, however, they are not allowed to know the identity of the
33 person that submits each card.
34
35 Once a winner is chosen, a new round is started with the previous
36 winner as the new leader. Play continues in this way until one of the
37 players reaches a predetermined winning score and is declared the
38 winner.
39
40 Each command returns information that is immediately useful to the
41 player who requested the command. In addition, any changes to their
42 hand or the set of cards players have submitted will be sent to them
43 via message so that they can easily recover state if they lose their
44 active session in the game.
45
46 Submitting cards and ending turns both require that the player submit
47 the round number that they intend for that action to apply to. If
48 that number does not match the current round the action will be
49 ignored and the command will return information to allow that player
50 to get back up to date with the game.
51 """
52
53 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
54
55 import random
56 import decks
57 from game_server.extensions import scoreboard
58 from game_server.extensions import card_game
59 from google.appengine.ext import db
60 from django.utils import simplejson
```

```
61
62  hand_size = 7
63  winning_score = 5
64  min_players = 3
65
66  #################
67  # Game Commands #
68  #################
69
70  def new_game_command(instance, player, arguments = None):
71    """ Start a new game of Androids to Androids.
72
73    Args:
74      instance: The GameInstance database model for this operation.
75      player: The player starting the game. Must be the current leader
76        of the instance instance.
77      arguments: Not used, can be any value.
78
79    Closes the game to new players, deals a new hand to each player and
80    selects a new characteristic card to begin round 1. Sends a new
81    game message to all players with the starting card and the empty
82    scoreboard.
83
84    Each player will also receive a message of type crd_hand that
85    contains all of the cards dealt to them.
86
87    Returns:
88      A three item list consisting of the new characteristic card for
89      this turn, the current (empty) scoreboard, and the requesting
90      player's current hand.
91
92    Raises:
93      ValueError if an Androids to Androids game is already in
94      progress, if player is not the current leader of the game or if
95      there are not enough players in the game to begin.
96    """
97    player = instance.check_leader(player)
98    instance.public = False
99
100   if 'ata_round' in instance.dynamic_properties():
101     raise ValueError("This game is already in progress. " +
102                      "Please refresh the game state.")
103
104   if len(instance.players) < min_players:
105     raise ValueError("Androids to Androids requires at least %d
      players."
106                      % min_players)
107
108   instance.max_players = len(instance.players)
109   try:
110     card_game.set_deck(instance, decks.noun_cards)
111   except AttributeError:
112     pass
113   card_game.shuffle_deck(instance)
```

```
  hands = card_game.deal_cards(instance, hand_size, True, False,
                               instance.players)

  instance.starting_players = instance.players
  instance.ata_round = 0
  setup_new_round(instance)
  board = scoreboard.clear_scoreboard_command(instance, player)
  instance.create_message(instance.leader, 'ata_new_game', '',
                          [instance.ata_char_card, board]).put()

  return [instance.ata_char_card, board, hands[player]]

def submit_card_command(instance, player, arguments):
  """ Submit a noun card for the current round.

  Args:
    instance: The GameInstance database model for this operation.
    player: The player submitting the card. Cannot be the leader.
    arguments: A two item list consisting of the round to submit this
      card for and the card itself.

  If the submission is for the wrong round, a four item list with an
  error string as its first element will be returned.  The remaining
  elements are the player's hand, the current round and the current
  characteristic card to respond to. No other action will be taken.

  Removes the indicated card from the player's hand and adds it
  to this round's submissions. The current submissions are sent via
  message to all players.

  The requesting player's hand will be dealt another card after
  removing the submitted one. The updated hand will be sent to the
  requesting player in a message and be included in the return value
  of this command.

  Returns:
    If the submission is for the correct round, returns a three item
    list consisting of the current round number, a list of the
    submissions made so far by other players in this round and the
    player's new hand.

  Raises:
    ValueError if player is the leader. The leader is not allowed to
    submit cards.
  """
  if int(arguments[0]) != instance.ata_round:
    hand = card_game.get_player_hand(instance, player)
    return ['You tried to submit a card for the wrong round. ' +
            'Please try again.', hand, instance.ata_round,
            instance.ata_char_card]

  missing_player = check_players(instance)
  if missing_player:
    return missing_player
```

```
168
169     if player == instance.leader:
170       raise ValueError("The leader may not submit a card.")
171
172     submission = arguments[1]
173     submissions = set_submission(instance, player, submission).values()
174     instance.create_message(player, 'ata_submissions', '',
175                             [instance.ata_round, submissions, submission
        ]).put()
176
177     card_game.discard(instance, player, [submission], False)
178     hand = card_game.draw_cards(instance, player, 1)
179     return [instance.ata_round, submissions, hand]
180
181   def end_turn_command(instance, player, arguments):
182     """ End the current turn and start a new one.
183
184     Args:
185       instance: The GameInstance database model for this operation.
186       player: The player submitting the card. Must be the current
187       leader.
188       arguments: A two item list consisting of the round number to end
189         and the selected winning card.
190
191     If the command is for the wrong round, a four item list with an
192     error string as its first element will be returned.  The remaining
193     elements are the player's hand, the current round and the current
194     characteristic card to respond to. No other action will be taken.
195
196     Ends the current turn and adds 1 point to the score of the player
197     who submitted the winning card. If that player has reached the
198     winning score, an 'ata_game_over' message will be sent to all
199     players.  The game over message content will be a three item list as
200     its contents. The list contains the final round number, the winning
201     card and the final scoreboard.
202
203     Otherwise, sends an 'ata_new_round' message to all players. The new
204     round message contents will be a five item list with the round
205     number, the new characteristic card, the previous round winner, the
206     winning card and the current scoreboard.
207
208     Returns:
209       If the command was for the correct round, returns the content of
210       whichever message was sent to all players as described above.
211     Raises:
212       ValueError if player is not the leader.
213       KeyError if no player has submitted the winning card.
214     """
215     if int(arguments[0]) != instance.ata_round:
216       hand = card_game.get_player_hand(instance, player)
217       return ['You tried to end a turn that has already ended. ' +
218               'Please try again.', hand, instance.ata_round,
219               instance.ata_char_card]
220
```

```
221   missing_player = check_players(instance)
222   if missing_player:
223     return missing_player
224
225   instance.check_leader(player)
226   card = arguments[1]
227   winner = None
228   for player, submitted_card in get_submissions_dict(instance).items()
        :
229     if card == submitted_card:
230       winner = player
231       break
232   if winner == None:
233     raise KeyError('No player has submitted the card %s.' % card)
234   board = scoreboard.add_to_score(instance, winner, 1)
235
236   # Check to see if anyone has won
237   instance.leader = winner
238   if board[winner] == winning_score:
239     return end_game(instance, card)
240
241   setup_new_round(instance)
242   return_scoreboard = scoreboard.format_scoreboard_for_app_inventor(
       board)
243   content = [instance.ata_char_card, return_scoreboard,
244              instance.ata_round, winner, card]
245   instance.create_message(instance.leader, 'ata_new_round', '',
       content).put()
246   return content
247
248 ###########
249 # Helpers #
250 ###########
251
252 def check_players(instance):
253   """ Checks to see if any of the starting players have left.
254
255   Args:
256     instance: The GameInstance model for this operation.
257
258   If a player has left the game, they are invited back and
259   a ValueError is raised.
260
261   Raises:
262     ValueError if a player has left the game.
263   """
264   if len(instance.players) < len(instance.starting_players):
265     for starting_player in instance.starting_players:
266       if starting_player not in instance.players:
267         instance.invited.append(starting_player)
268         return ('%s left during your game. They have ' %
269                 starting_player +
270                 'been invited and must rejoin before continuing.')
271   return False
```

```
272
273 def end_game(instance, winning_card):
274   """ End the current game and inform all players of the winner.
275
276   Args:
277     instance: The GameInstance database model for this operation.
278     winning_card: The card chosen as the winner of the final round.
279
280   Sends an 'ata_game_over' message from the winner to all players with
281   a three item list as its contents. The list contains the final round
282   number, the winning card and the final scoreboard.
283
284   Deletes the ata_round, ata_char_card and ata_submissions properties
285   from the GameInstance database model to allow for a new game to be
286   player in this same instance with the previous winner as the new
287   leader.
288
289   Returns:
290     The content of the message sent to all players.
291   """
292   content = [instance.ata_round, winning_card,
293              scoreboard.get_scoreboard_command(instance, instance.
      leader)]
294   instance.create_message(instance.leader, 'ata_game_over', '',
      content).put()
295   del instance.ata_round
296   del instance.ata_char_card
297   del instance.ata_submissions
298   instance.scoreboard = '{}'
299   return content
300
301 def setup_new_round(instance):
302   """ Update the round number, char card and submissions for a new
      round.
303
304   Args:
305     instance: The GameInstance database model for this operation.
306
307   Increments ata_round, clears the submissions dictionary and sets
308   ata_char_card to a new value from the list of characteristic cards.
309   """
310   instance.ata_round += 1
311   instance.ata_submissions = db.Text('{}')
312
313   new_card = random.choice(decks.characteristic_cards)
314   if 'ata_char_card' in instance.dynamic_properties():
315     while instance.ata_char_card == new_card:
316       new_card = random.choice(decks.characteristic_cards)
317   instance.ata_char_card = new_card
318
319 def get_submissions_dict(instance):
320   """ Return a Python dictionary that maps cards to players.
321
322   Args:
```

```
    instance: The GameInstance database model for this operation.

  Returns:
    A Python dictionary of cards to players for all cards
    submitted so far during this round.
  """
  return simplejson.loads(instance.ata_submissions)

def set_submission(instance, player, card):
  """ Records the submission of card as coming from player.

  Args:
    instance: The GameInstance database model for this operation.
    player: The player submitting the card.
    card: The card to submit.

  Returns:
    A Python dictionary of cards to players for all cards
    submitted so far during this round.
  """
  submissions = get_submissions_dict(instance)
  if player in submissions:
    raise ValueError('You have already submitted a card for this round
    .')
  submissions[player] = card
  instance.ata_submissions = simplejson.dumps(submissions)
  return submissions
```

A.2.3 Bulls and Cows

A.12: bac_commands.py - Bulls and Cows game commands.

```
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# distributed under the License is distributed on an "AS IS" BASIS,
# WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
    implied.
# See the License for the specific language governing permissions and
# limitations under the License.
"""
A version of bulls and cows using colors.

At the beginning of a new game a solution sequence of four colors is
randomly chosen from the set of colors. Each color appears at most
once in the solution. The player then makes guesses on the sequence
of colors in the solution. After each guess, they are informed of how
```

```
20 many 'cows' and 'bulls' they have in their guess. A 'bull' is when a
21 player has the correct color in the correct position in their guess.A
22 'cow' is when a player has one of the correct colors, but it is in
23 the wrong position.
24
25 Although the solution only includes each color once, a player is
26 allowed to use the same color more than once in their guess. While
27 obviously not correct, doing so might give the player information
28 that they want about the solution.
29
30 The player begins with a score such that they will end with a score
31 of zero if they guess completely wrong every time. After each guess
32 is made, two points are deducted for each completely wrong color and
33 one point is deducted for a correct color in the wrong spot (a
34 cow). No points are deducted for a bull. If a player does not
35 determine the correct sequence before they run out of guesses they
36 are not awarded a score.  """
37
38 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
39
40 from random import sample
41 from django.utils import simplejson
42 from game_server.extensions import scoreboard
43 from game_server.models.message import Message
44 from google.appengine.ext import db
45 from google.appengine.ext.db import Key
46
47 starting_guesses = 12
48 solution_size = 4
49 colors = ['Blue', 'Green', 'Orange', 'Red', 'Yellow', 'Pink']
50
51 def new_game_command(instance, player, arguments = None):
52   """ Start a new game and reset any game in progress.
53
54   Args:
55     instance: The GameInstance database model for this operation.
56     player: The player starting a new game. Must be the only player
57       in the instance.
58     arguments: Not used, can be any value.
59
60   Returns:
61     A list containing the number of guesses remaining, the starting
62     score of the player, the player's historical high score and the
63     number of games completed in the past.
64
65   Raises:
66     ValueError if there is more than 1 player in the instance
67     or the player is not the current leader.
68   """
69   old_games = instance.get_messages_query('bac_game', player,
70                                           sender = player,
71                                           keys_only = True)
72   db.delete(old_games)
73
```

```
74    score = scoreboard.get_score(instance, player)
75    if (score == 0):
76      # Score is [high score, total score, games played]
77      score = [0, 0, 0]
78      scoreboard.set_score(instance, player, score)
79
80    game = Message(parent = instance, sender = player,
81                   msg_type = 'bac_game', recipient = player)
82    game.bac_solution = sample(colors, solution_size)
83    game.bac_guesses_remaining = starting_guesses
84    game.bac_score = solution_size * starting_guesses * 2
85    game.bac_last_guess = ['']
86    game.bac_last_reply = ''
87    game.put()
88
89    return [game.bac_guesses_remaining, game.bac_score, score,
90            game.key().id()]
91
92  def guess_command(instance, player, arguments):
93    """ Evaluate a guess and determine the score.
94
95    Args:
96      instance: The GameInstance database model for this operation.
97      player: The player making the guess. Must be the leader of
98        the instance.
99      arguments: A two element list containg the game id and a second
100       list with the guessed colors.
101
102   new_game_command must be invoked before a guess can be made.
103
104   Returns:
105     If the player has guessed correctly:
106       A two element list containg a score list and a boolean of
107       whether or not this game set a new high score. The score list is
108       a three element list containing the player's high score, their
109       total score and their total number of games played.
110
111     Otherwise:
112       A four element list containing the player's remaining score, the
113       number of guesses remaining, the number of bulls for this guess
114       and the number of cows for this guess.
115
116   Raises:
117     ValueError if the player is not the current instance leader and
118     only member of the game.
119     ValueError if the player has no guesses remaining.
120     ValueError if the guess does not have the correct number of
121     elements.
122     ValueError if no game has been started yet.
123   """
124   guess = arguments[1]
125   if len(guess) != solution_size:
126     raise ValueError("Guess was not the right number of elements.")
127
```

```
128   game = db.get(Key.from_path('Message', int(arguments[0]),
129                               parent = instance.key()))
130
131   if game is None:
132     raise ValueError("Game not found. Please start a new game.")
133   if game.sender != player:
134     raise ValueError("This is not your game. Please start a new game."
      )
135
136   if guess == game.bac_last_guess:
137     return simplejson.loads(game.bac_last_reply)
138
139   if game.bac_guesses_remaining == 0:
140     raise ValueError("No turns left, please start a new game.")
141
142   return_content = None
143
144   if guess == game.bac_solution:
145     game.bac_guesses_remaining = 0
146     new_high_score = False
147     score = scoreboard.get_score(instance, player)
148     if game.bac_score > score[0]:
149       new_high_score = True
150       score[0] = game.bac_score
151     score[1] = score[1] + game.bac_score
152     score[2] = score[2] + 1
153     scoreboard.set_score(instance, player, score)
154     return_content = [score, new_high_score]
155   else:
156     game.bac_guesses_remaining -= 1
157     bulls = cows = 0
158     for i in xrange(solution_size):
159       if guess[i] == game.bac_solution[i]:
160         bulls += 1
161       elif guess[i] in game.bac_solution:
162         cows += 1
163
164     score_deduction = solution_size * 2 - cows - 2 * bulls
165     game.bac_score -= score_deduction
166     return_content = [game.bac_guesses_remaining, game.bac_score,
167                       bulls, cows]
168   game.bac_last_reply = simplejson.dumps(return_content)
169   game.bac_last_guess = guess
170   game.put()
171   return return_content
```

A.2.4 Voting

A.13: voting_commands.py - Voting commands.

```
1  # Copyright 2010 Google Inc.
2  # Licensed under the Apache License, Version 2.0 (the "License");
```

```
3  # you may not use this file except in compliance with the License.
4  # You may obtain a copy of the License at
5
6  #      http://www.apache.org/licenses/LICENSE-2.0
7
8  # Unless required by applicable law or agreed to in writing, software
9  # distributed under the License is distributed on an "AS IS" BASIS,
10 # WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
       implied.
11 # See the License for the specific language governing permissions and
12 # limitations under the License.
13 """ Commands for a voting application.
14
15 The commands are split into two categories. The first is for people
16 who are performing the voting. The second category is for the
17 creation and management of polls.
18
19 Voting:
20 Players find out about new polls by retrieving messages with types
21 'poll' or 'closed_poll' from the instance.
22
23 Once a player has found out about polls, they can cast votes and
24 get results for closed polls and polls they have already voted in.
25
26 When a player votes in a poll they immediately receive the current
27 results of that poll. They will be able to fetch those results until
28 the poll creator deletes the poll.
29
30 Poll Management:
31 The remaining commands are for managing polls. Polls can be
32 created, closed and deleted. Players can get the polls they have
33 created with the get my polls command.
34 """
35
36 __authors__ = ['"Bill Magnuson" <billmag@mit.edu>']
37
38 from django.utils import simplejson
39 from game_server.models.message import Message
40 from google.appengine.ext import db
41
42 def cast_vote_command(instance, player, arguments):
43   """ Cast a vote in a poll and return its current results.
44
45   Args:
46     instance: The parent GameInstance model of this poll.
47     player: The player that is casting a vote.
48     arguments: A two item list of the poll id and the zero
49       based index of the option to select.
50
51   Returns:
52     A two item list contaning a message and the current votes
53     for the poll. The message will be one of:
54       Your vote was already counted in this poll.
55       Poll closed to new votes.
```

```
56        Vote accepted.
57
58    Raises:
59      ValueError if the vote index is larger than the number
60      of options.
61      ValueError if the player is not in the instance.
62    """
63
64
65    instance.check_player(player)
66    poll = get_poll(instance, arguments[0])
67
68    if not poll.open:
69      return ['Poll closed to new votes.', poll.votes]
70    if player in poll.voters:
71      return ['Your vote was already counted in this poll.', poll.votes]
72
73    try:
74      poll.voters.append(player)
75      vote_index = int(arguments[1])
76      poll.votes[vote_index] += 1
77      poll.put()
78    except ValueError:
79      raise ValueError('Invalid vote choice.')
80    return ['Vote accepted.', poll.votes]
81
82  def get_results_command(instance, player, arguments):
83    """ Gets the results of a poll.
84
85    Args:
86      instance: The parent GameInstance model of the poll.
87      player: The player requesting the results.
88      arguments: A one item list containing the id number of the poll.
89
90    Returns:
91      If the player has not voted in this poll and it is still open,
92      this will return a single item list with a message for the
93      requesting player.
94      Otherwise returns a list with information about the poll. See
95      get_poll_return_list for its format.
96
97    Raises:
98      ValueError if the player is not in the instance.
99    """
100   instance.check_player(player)
101   poll = get_poll(instance, arguments[0])
102   if not poll.open:
103     return ['Poll is now closed.', poll.votes]
104   if player in poll.voters:
105     return ['You have already voted in this poll.', poll.votes]
106   return ['You have not voted in this poll yet.']
107
108 def make_new_poll_command(instance, player, arguments):
109   """ Make a new poll.
```

```
110
111     Args:
112       instance: The game instance to add the poll to.
113       player: The email of the player creating the poll.
114       arguments: A two item list containing the question and a
115         second list of 2-5 options.
116
117     Returns:
118       Returns a list with information about the poll just created.
119       See get_poll_return_list for its format.
120
121     Raises:
122       ValueError if the player is not in the instance.
123     """
124     instance.check_player(player)
125     if not arguments[0]:
126       raise ValueError('Question cannot be empty')
127     size = len(arguments[1])
128     if size < 2 or size > 5:
129       raise ValueError('Incorrect number of options for poll. ' +
130                        'Must be between two and five.')
131
132     poll = Message(parent = instance, sender = player,
133                    msg_type = 'poll', recipient = '')
134     poll.put()
135     arguments.append(poll.key().id())
136     poll.content = simplejson.dumps(arguments)
137     poll.votes = [0] * size
138     poll.open = True
139     poll.voters = ['']
140     poll.put()
141     return get_poll_return_list(poll)
142
143 def close_poll_command(instance, player, arguments):
144     """ Close an existing poll.
145
146     Args:
147       instance: The parent GameInstance model of the poll.
148       player: The email of the player closing the poll. Must be the
149         poll's creator.
150       arguments: A one argument list with the poll's id number.
151
152     Returns:
153       A list with information about the poll just closed. See
154       get_poll_return_list for its format.
155
156     Raises:
157       ValueError if player is not the creator of the poll.
158       ValueError if the player is not in the instance.
159     """
160     instance.check_player(player)
161     poll = get_poll(instance, arguments[0])
162     if poll.sender != player:
163       raise ValueError('Only the person that created this poll may close
```

```
      it.')
164   poll.open = False
165   poll.msg_type = 'closed_poll'
166   poll.put()
167   return get_poll_return_list(poll)
168
169 def delete_poll_command(instance, player, arguments):
170   """ Delete an existing poll.
171
172   Args:
173     instance: The parent GameInstance model of the poll.
174     player: The email of the player closing the poll. Must be the
175       poll's creator.
176     arguments: A one argument list with the poll's id number.
177
178   Returns:
179     True if the deletion is successful.
180
181   Raises:
182     ValueError if player is not the creator of the poll.
183     ValueError if the player is not in the instance.
184   """
185   instance.check_player(player)
186   poll = get_poll(instance, arguments[0])
187   if poll.sender != player:
188     raise ValueError('Only the person that created this poll may
      delete it.')
189   db.delete(poll)
190   return [True]
191
192 def get_poll_info_command(instance, player, arguments):
193   """ Get information about an existing poll.
194
195   Args:
196     instance: The parent GameInstance model of the poll.
197     player: The email of the player requesting information. Must
198       be the poll's creator.
199     arguments: A one argument list with the poll's id number.
200
201   Returns:
202     A list with information about the poll. See
203     get_poll_return_list for its format.
204
205   Raises:
206     ValueError if player is not the creator of the poll.
207   Raises:
208     ValueError if the player is not in the instance.
209   """
210   instance.check_player(player)
211   poll = get_poll(instance, arguments[0])
212   if poll.sender != player:
213     raise ValueError('Only the person that created the poll can'
214       + 'request its information.')
215   return get_poll_return_list(poll)
```

```
216
217 def get_my_polls_command(instance, player, arguments = None):
218   """ Get the polls created by a player in the instance.
219
220   Args:
221     instance: The parent GameInstance model of the polls.
222     player: The email of the player requesting the polls.
223     arguments: Not used, can be any value.
224
225   Finds all polls created by this player.
226
227   Returns:
228     A list of two item lists with each containing the
229     id number of the poll and its question.
230
231   Raises:
232     ValueError if the player is not in the instance.
233   """
234   instance.check_player(player)
235   query = instance.get_messages_query('', '', sender = player)
236   polls = query.fetch(1000)
237   return [[poll.key().id(), poll.get_content()[0]] for poll in polls[:
      :-1]]
238
239 def get_poll(instance, argument):
240   """ Get a poll database model.
241
242   Args:
243     instance: The parent GameInstance database model of the poll.
244     argument: The poll id argument from the server command
245       arguments list.
246
247   Returns:
248     A Message database model of the poll.
249
250   Raises:
251     ValueError if argument fails to parse to an int or the
252     poll doesn't exist in the database.
253   """
254   try:
255     poll_id = int(argument)
256   except ValueError:
257     raise ValueError('Poll id failed to parse to a number.')
258
259   poll_key = db.Key.from_path('Message', poll_id,
260                               parent = instance.key())
261   poll = db.get(poll_key)
262
263   if poll is None:
264     raise ValueError('Poll no longer exists.')
265   return poll
266
267 def get_poll_return_list(poll):
268   """ Get a list to return to the GameClient component for a poll.
```

```
269
270     Args:
271       poll: A Message database model that is a poll.
272
273     Returns:
274       A list with the following five items:
275         The poll question.
276         The poll options as a list.
277         The poll id number.
278         The poll votes as a list.
279         Whether the poll is open.
280     """
281     content = poll.get_content()
282     content.extend([poll.votes, poll.open])
283     return content
```

Appendix B

Game Client Code

This appendix includes selected JAVA source files from the App Inventor component runtime. Source code in this appendix is not presented in its directory structure as in Appendix A.

B.1 Game Client Component

B.1: GameClient.java - The Game Client component.

```
1  // Copyright 2009 Google Inc. All Rights Reserved.
2
3  package com.google.devtools.simple.runtime.components.android;
4
5  import com.google.devtools.simple.common.ComponentCategory;
6  import com.google.devtools.simple.runtime.annotations.
       DesignerComponent;
7  import com.google.devtools.simple.runtime.annotations.DesignerProperty
       ;
8  import com.google.devtools.simple.runtime.annotations.SimpleEvent;
9  import com.google.devtools.simple.runtime.annotations.SimpleFunction;
10 import com.google.devtools.simple.runtime.annotations.SimpleObject;
11 import com.google.devtools.simple.runtime.annotations.SimpleProperty;
12 import com.google.devtools.simple.runtime.annotations.UsesPermissions;
13 import com.google.devtools.simple.runtime.components.android.collect.
       Lists;
14 import com.google.devtools.simple.runtime.components.android.util.
       AsyncCallbackPair;
15 import com.google.devtools.simple.runtime.components.android.util.
       AsynchUtil;
16 import com.google.devtools.simple.runtime.components.android.util.
       GameInstance;
```

```
17 import com.google.devtools.simple.runtime.components.android.util.
       LoginServiceUtil;
18 import com.google.devtools.simple.runtime.components.android.util.
       PlayerListDelta;
19 import com.google.devtools.simple.runtime.components.android.util.
       WebServiceUtil;
20 import com.google.devtools.simple.runtime.components.util.JsonUtil;
21 import com.google.devtools.simple.runtime.components.util.YailList;
22 import com.google.devtools.simple.runtime.errors.YailRuntimeError;
23 import com.google.devtools.simple.runtime.events.EventDispatcher;
24
25 import android.app.Activity;
26 import android.os.Handler;
27 import android.util.Log;
28
29 import org.apache.http.NameValuePair;
30 import org.apache.http.message.BasicNameValuePair;
31 import org.json.JSONArray;
32 import org.json.JSONException;
33 import org.json.JSONObject;
34
35 import java.util.ArrayList;
36 import java.util.List;
37
38 /**
39  * GameClient provides a way for AppInventor applications to
40  * communicate with online game servers. This allows users to create
41  * games that are coordinated and managed in the cloud.
42  *
43  * Most communication is done by sending keyed messages back and
44  * forth between the client and the server in the form of YailLists.
45  * The server and game client can then switch on the keys and perform
46  * more complex operations on the data. In addition, game servers can
47  * implement a library of server commands that can perform complex
48  * functions on the server and send back responses that are converted
49  * into YailLists and sent back to the component. For more
50  * information about server commands, consult the game server code
51  * at http://code.google.com/p/app-inventor-for-android/
52  *
53  * Games instances are uniquely determined by a game id and an
54  * instance id. In general, each App Inventor program should have
55  * its own game id. Then, when running different instances of that
56  * program, new instance ides should be used. Players are
57  * represented uniquely by the email address registered to their
58  * phones.
59  *
60  * All call functions perform POSTs to a web server. Upon successful
61  * completion of these POST requests, FunctionCompleted will be
62  * triggered with the function name as an argument. If the post
63  * fails, WebServiceError will trigger with the function name and the
64  * error message as arguments. These calls allow for application
65  * creators to deal with web service failures and keep track of the
66  * success or failure of theie operations. The only exception to this
67  * is when the return value from the server has the incorrect game id
```

```
68   * or instance id. In this case, the response is completely ignored
69   * and neither of these events will trigger.
70   *
71   * @author billmag@google.com (Bill Magnuson)
72   *
73   */
74  @DesignerComponent(
75      description = "Provides a way for applications to communicate with
         online game servers",
76      category = ComponentCategory.EXPERIMENTAL)
77  @SimpleObject
78  @UsesPermissions(
79      permissionNames = "android.permission.INTERNET, com.google.android
        .googleapps.permission.GOOGLE_AUTH")
80  public class GameClient implements OnResumeListener, OnStopListener {
81
82    private static final String LOG_TAG = "GameClient";
83
84    // Parameter keys
85    private static final String GAME_ID_KEY = "gid";
86    private static final String INSTANCE_ID_KEY = "iid";
87    private static final String PLAYER_ID_KEY = "pid";
88    private static final String INVITEE_KEY = "inv";
89    private static final String LEADER_KEY = "leader";
90    private static final String COUNT_KEY = "count";
91    private static final String TYPE_KEY = "type";
92    private static final String INSTANCE_PUBLIC_KEY = "makepublic";
93    private static final String MESSAGE_RECIPIENTS_KEY = "mrec";
94    private static final String MESSAGE_CONTENT_KEY = "contents";
95    private static final String MESSAGE_TIME_KEY = "mtime";
96    private static final String MESSAGE_SENDER_KEY = "msender";
97    private static final String COMMAND_TYPE_KEY = "command";
98    private static final String COMMAND_ARGUMENTS_KEY = "args";
99    private static final String SERVER_RETURN_VALUE_KEY = "response";
100   private static final String MESSAGES_LIST_KEY = "messages";
101   private static final String ERROR_RESPONSE_KEY = "e";
102   private static final String PUBLIC_LIST_KEY = "public";
103   private static final String JOINED_LIST_KEY = "joined";
104   private static final String INVITED_LIST_KEY = "invited";
105   private static final String PLAYERS_LIST_KEY = "players";
106
107   // Command keys
108   private static final String GET_INSTANCE_LISTS_COMMAND = "
        getinstancelists";
109   private static final String GET_MESSAGES_COMMAND = "messages";
110   private static final String INVITE_COMMAND = "invite";
111   private static final String JOIN_INSTANCE_COMMAND = "joininstance";
112   private static final String LEAVE_INSTANCE_COMMAND = "leaveinstance"
        ;
113   private static final String NEW_INSTANCE_COMMAND = "newinstance";
114   private static final String NEW_MESSAGE_COMMAND = "newmessage";
115   private static final String SERVER_COMMAND = "servercommand";
116   private static final String SET_LEADER_COMMAND = "setleader";
117
```

```
118   // URL for accessing the game server
119   private String serviceUrl;
120   private String gameId;
121   private GameInstance instance;
122   private Handler androidUIHandler;
123   private Activity activityContext;
124
125   private String userEmailAddress = "";
126
127   // Game instances in the current GameId that this player has joined
128   private List<String> joinedInstances;
129   // Game instances to which this player has been invited
130   private List<String> invitedInstances;
131   // Game instances which have been made public.
132   private List<String> publicInstances;
133
134   /**
135    * Creates a new GameClient component.
136    *
137    * @param container the Form that this component is contained in.
138    */
139   public GameClient(ComponentContainer container) {
140     // Note that although this is creating a new Handler there is
141     // only one UI thread in an Android app and posting to this
142     // handler queues up a Runnable for execution on that thread.
143     androidUIHandler = new Handler();
144     activityContext = container.$context();
145     Form form = container.$form();
146     form.registerForOnResume(this);
147     form.registerForOnStop(this);
148     gameId = "";
149     instance = new GameInstance("");
150     joinedInstances = Lists.newArrayList();
151     invitedInstances = Lists.newArrayList();
152     publicInstances = Lists.newArrayList();
153     serviceUrl = "http://appinvgameserver.appspot.com";
154
155     // This needs to be done in a separate thread since it uses
156     // a blocking service to complete and will cause the UI to hang
157     // if it happens in the constructor.
158     AsynchUtil.runAsynchronously(new Runnable() {
159       @Override
160       public void run() {
161         userEmailAddress = LoginServiceUtil.getPhoneEmailAddress(
      activityContext);
162         if (!userEmailAddress.equals("")) {
163           UserEmailAddressSet(userEmailAddress);
164         }
165       }
166     });
167   }
168
169
170   //-------------------------------------------------------------
```

```
171   // Properties
172
173   /**
174    * Returns a string indicating the game name for this application.
175    * The same game ID can have one or more game instances.
176    */
177   @SimpleProperty
178   public String GameId() {
179     return gameId;
180   }
181
182   /**
183    * Specifies a string indicating the family of the current game
184    * instance.  The same game ID can have one or more game instance
185    * IDs.
186    */
187   // Only exposed in the designer to enforce that each GameClient
188   // instance should be made for a single GameId.
189   @DesignerProperty(
190       editorType = DesignerProperty.PROPERTY_TYPE_STRING,
191       defaultValue = "\"\"")
192   public void GameId(String id) {
193     this.gameId = id;
194   }
195
196   /**
197    * Returns the game instance id.  Taken together, the game ID and
198    * the instance ID uniquely identify the game.
199    */
200   @SimpleProperty
201   public String InstanceId() {
202     return instance.getInstanceId();
203   }
204
205   /**
206    * Returns the set of game instances to which this player has been
207    * invited but has not yet joined.  To ensure current values are
208    * returned, first invoke {@link #GetInstanceLists}.
209    */
210   @SimpleProperty
211   public List<String> InvitedInstances() {
212     return invitedInstances;
213   }
214
215   /**
216    * Returns the set of game instances in which this player is
217    * participating.  To ensure current values are returned, first
218    * invoke {@link #GetInstanceLists}.
219    */
220   @SimpleProperty
221   public List<String> JoinedInstances() {
222     return joinedInstances;
223   }
224
```

```
225   /**
226    * Returns the game's leader. At any time, each game instance has
227    * only one leader, but the leader may change with time.
228    * Initially, the leader is the game instance creator. Application
229    * writers determine special properties of the leader. The leader
230    * value is updated each time a successful communication is made
231    * with the server.
232    */
233   @SimpleProperty
234   public String Leader() {
235     return instance.getLeader();
236   }
237
238   /**
239    * Returns the current set of players for this game instance. Each
240    * player is designated by an email address, which is a string. The
241    * list of players is updated each time a successful communication
242    * is made with the game server.
243    */
244   @SimpleProperty
245   public List<String> Players() {
246     return instance.getPlayers();
247   }
248
249   /**
250    * Returns the set of game instances that have been marked public.
251    * To ensure current values are returned, first
252    * invoke {@link #GetInstanceLists}.
253    */
254   @SimpleProperty
255   public List<String> PublicInstances() {
256     return publicInstances;
257   }
258
259   /**
260    * The URL of the game server.
261    *
262    */
263   @SimpleProperty
264   public String ServiceUrl() {
265     return serviceUrl;
266   }
267
268   /**
269    * Set the URL of the game server.
270    *
271    * @param url The URL (include initial http://).
272    */
273   @DesignerProperty(
274       editorType = DesignerProperty.PROPERTY_TYPE_STRING,
275       defaultValue = "\"http://appinvgameserver.appspot.com\"")
276   public void ServiceURL(String url){
277     if (url.endsWith("/")) {
278       this.serviceUrl = url.substring(0, url.length() - 1);
```

```
279       } else {
280         this.serviceUrl = url;
281       }
282     }
283
284     /**
285      * Returns the registered email address that is being used as the
286      * player id for this game client.
287      */
288     @SimpleProperty
289     public String UserEmailAddress() {
290       if (userEmailAddress.equals("")) {
291         Info("User email address is empty.");
292       }
293       return userEmailAddress;
294     }
295
296     /**
297      * Changes the player of this game by changing the email address
298      * used to communicate with the server.
299      *
300      * This should only be used during development. Games should not
301      * allow players to set their own email address.
302      *
303      * @param emailAddress The email address to set the current player
304      * id to.
305      */
306     @SimpleProperty
307     public void UserEmailAddress(String emailAddress) {
308       userEmailAddress = emailAddress;
309       UserEmailAddressSet(emailAddress);
310     }
311
312     //-------------------------------------------------------------------
313     // Event Handlers
314
315     /**
316      * Indicates that a server request from a function call has
317      * completed. This can be used to control a polling loop or
318      * otherwise respond to server request completions.
319      *
320      * @param functionName The name of the App Inventor function that
321      * finished.
322      */
323     @SimpleEvent(description = "Indicates that a function call completed
        .")
324     public void FunctionCompleted(final String functionName) {
325       androidUIHandler.post(new Runnable() {
326         public void run() {
327           Log.d(LOG_TAG, "Request completed: " + functionName);
328           EventDispatcher.dispatchEvent(GameClient.this, "
        FunctionCompleted", functionName);
329         }});
330     }
```

```
331
332   /**
333    * Default Initialize event handler.  Ensures that the GameId was
334    * set by the game creator.
335    */
336   @SimpleEvent
337   public void Initialize() {
338     Log.d(LOG_TAG, "Initialize");
339     if (gameId.equals("")) {
340       throw new YailRuntimeError("Game Id must not be empty.", "
      GameClient Configuration Error.");
341     }
342     EventDispatcher.dispatchEvent(this, "Initialize");
343   }
344
345   /**
346    * Indicates that a GetMessages call received a message. This could
347    * be invoked multiple times for a single call to GetMessages.
348    *
349    * @param type The type of the message received.
350    * @param contents The message's contents. Consists of a list
351    * nested to arbitrary depth that includes string, boolean and
352    * number values.
353    */
354   @SimpleEvent(description = "Indicates that a new message has " +
355       "been received.")
356   public void GotMessage(final String type, final String sender, final
       List<Object> contents) {
357     Log.d(LOG_TAG, "Got message of type " + type);
358     androidUIHandler.post(new Runnable() {
359       public void run() {
360         EventDispatcher.dispatchEvent(GameClient.this, "GotMessage",
      type, sender, contents);
361       }});
362   }
363
364   /**
365    * Indicates that InstanceId has changed due to the creation of a
366    * new instance or setting the InstanceId.
367    *
368    * @param instanceId The id of the instance the player is now in.
369    */
370   @SimpleEvent(description = "Indicates that the InstanceId " +
371       "property has hanged as a result of calling " +
372       "MakeNewInstance or SetInstance.")
373   public void InstanceIdChanged(final String instanceId) {
374     Log.d(LOG_TAG, "Instance id changed to " + instanceId);
375     androidUIHandler.post(new Runnable() {
376       public void run() {
377         EventDispatcher.dispatchEvent(GameClient.this, "
      InstanceIdChanged", instanceId);
378       }});
379   }
380
```

```
381   /**
382    * Indicates a user has been invited to this game instance by
383    * another player.
384    *
385    * @param instanceId The id of the new game instance.
386    */
387   @SimpleEvent(
388       description = "Indicates that a user has been invited to " +
389           "this game instance.")
390   public void Invited(final String instanceId) {
391     Log.d(LOG_TAG, "Player invited to " + instanceId);
392     androidUIHandler.post(new Runnable() {
393       public void run() {
394         EventDispatcher.dispatchEvent(GameClient.this, "Invited",
      instanceId);
395       }});
396   }
397
398   /**
399    * Indicates this game instance has a new leader. This could happen
400    * in response to a call to SetLeader or by the side effects of a
401    * server command performed by any player in the game.
402    *
403    * Since the current leader is sent back with every server
404    * response, NewLeader can trigger after making any server call.
405    *
406    * @param playerId The email address of the new leader.
407    */
408   @SimpleEvent(description = "Indicates that this game has a new " +
409       "leader as specified through SetLeader")
410   public void NewLeader(final String playerId) {
411     androidUIHandler.post(new Runnable() {
412       public void run() {
413         Log.d(LOG_TAG, "Leader change to " + playerId);
414         EventDispatcher.dispatchEvent(GameClient.this, "NewLeader",
      playerId);
415       }});
416   }
417
418   /**
419    * Indicates this game instance was created as specified via
420    * MakeNewInstance. The creating player is automatically the leader
421    * of the instance and the InstanceId property has already been set
422    * to this new instance.
423    *
424    * @param instanceId The id of the newly created game instance.
425    */
426   @SimpleEvent(description = "Indicates that a new instance was " +
427       "successfully created after calling MakeNewInstance.")
428   public void NewInstanceMade(final String instanceId) {
429     androidUIHandler.post(new Runnable() {
430       public void run() {
431         Log.d(LOG_TAG, "New instance made: " + instanceId);
```

```
432         EventDispatcher.dispatchEvent(GameClient.this, "
      NewInstanceMade", instanceId);
433       }});
434   }
435
436   /**
437    * Indicates that a player has joined this game instance.
438    *
439    * @param playerId The email address of the new player.
440    */
441   @SimpleEvent(description = "Indicates that a new player has " +
442       "joined this game instance.")
443   public void PlayerJoined(final String playerId) {
444     androidUIHandler.post(new Runnable() {
445       public void run() {
446         if (!playerId.equals(UserEmailAddress())) {
447           Log.d(LOG_TAG, "Player joined: " + playerId);
448           EventDispatcher.dispatchEvent(GameClient.this, "PlayerJoined
      ", playerId);
449         }
450       }});
451   }
452
453   /**
454    * Indicates that a player has left this game instance.
455    *
456    * @param playerId The email address of the player that left.
457    */
458   @SimpleEvent(description = "Indicates that a player has left " +
459       "this game instance.")
460   public void PlayerLeft(final String playerId) {
461     androidUIHandler.post(new Runnable() {
462       public void run() {
463         Log.d(LOG_TAG, "Player left: " + playerId);
464         EventDispatcher.dispatchEvent(GameClient.this, "PlayerLeft",
      playerId);
465       }});
466   }
467
468   /**
469    * Indicates that an attempt to complete a server command failed on
470    * the server.
471    * @param command The command requested.
472    * @param arguments The arguments sent to the command.
473    */
474   @SimpleEvent(
475       description = "Indicates that a server command failed.")
476   public void ServerCommandFailure(final String command, final
      YailList arguments) {
477     androidUIHandler.post(new Runnable() {
478       public void run() {
479         Log.d(LOG_TAG, "Server command failed: " + command);
480         EventDispatcher.dispatchEvent(GameClient.this, "
      ServerCommandFailure", command, arguments);
```

```
481         }});
482     }
483
484     /**
485      * Indicates that a ServerCommand completed.
486      *
487      * @param command The key for the command that resulted in this
488      * response.
489      * @param response The server response. This consists of a list
490      * nested to arbitrary depth that includes string, boolean and
491      * number values.
492      */
493     @SimpleEvent(description = "Indicates that a server command " +
494         "returned successfully.")
495     public void ServerCommandSuccess(final String command, final List<
          Object> response) {
496       Log.d(LOG_TAG, command + " server command returned.");
497       androidUIHandler.post(new Runnable() {
498         public void run() {
499           EventDispatcher.dispatchEvent(GameClient.this,
500               "ServerCommandSuccess", command, response);
501         }});
502     }
503
504     /**
505      * Indicates that the user email address property has been
506      * successfully set. This event should be used to initialize
507      * any web service functions.
508      *
509      * This separate event was required because the email address was
510      * unable to be first fetched from the the UI thread without
511      * causing programs to hang. GameClient will now start fetching
512      * the user email address in its constructor and trigger this event
513      * when it finishes.
514      */
515     @SimpleEvent(description = "Indicates that the user email " +
516         "address has been set.")
517     public void UserEmailAddressSet(final String emailAddress) {
518       Log.d(LOG_TAG, "Email address set.");
519       androidUIHandler.post(new Runnable() {
520         public void run() {
521           EventDispatcher.dispatchEvent(GameClient.this, "
          UserEmailAddressSet", emailAddress);
522         }});
523     }
524
525     //-------------------------------------------------------------------
526     // Message events
527
528     /**
529      * Indicates that something has occurred which the player should be
530      * somehow informed of.
531      *
532      * @param message the message.
```

```
533     */
534   @SimpleEvent(description = "Indicates that something has " +
535       "occurred which the player should know about.")
536   public void Info(final String message) {
537     Log.d(LOG_TAG, "Info: " + message);
538     androidUIHandler.post(new Runnable() {
539       public void run() {
540         EventDispatcher.dispatchEvent(GameClient.this, "Info", message
      );
541       }});
542
543   }
544
545   /**
546    * Indicates that the attempt to communicate with the web service
547    * resulted in an error.
548    *
549    * @functionName The name of the function call that caused this
550    * error.
551    * @param message the error message
552    */
553   @SimpleEvent(description = "Indicates that an error occurred " +
554       "while communicating with the web server.")
555   public void WebServiceError(final String functionName, final String
      message) {
556     Log.e(LOG_TAG, "WebServiceError: " + message);
557     androidUIHandler.post(new Runnable() {
558       public void run() {
559         EventDispatcher.dispatchEvent(GameClient.this, "
      WebServiceError", functionName, message);
560       }});
561   }
562
563   //-------------------------------------------------------------------
564   // Functions
565
566   /**
567    * Updates the current InstancesJoined and InstancesInvited lists.
568    *
569    * If the player has been invited to new instances an Invited
570    * event will be raised for each new instance.
571    */
572   @SimpleFunction(description = "Updates the InstancesJoined and " +
573       "InstancesInvited lists. This procedure can be called " +
574       "before setting the InstanceId.")
575   public void GetInstanceLists() {
576     AsynchUtil.runAsynchronously(new Runnable() {
577         public void run() { postGetInstanceLists(); }});
578   }
579
580   private void postGetInstanceLists() {
581     AsyncCallbackPair<JSONObject> readMessagesCallback = new
      AsyncCallbackPair<JSONObject>(){
582       public void onSuccess(final JSONObject response) {
```

```
583         processInstanceLists(response);
584         FunctionCompleted("GetInstanceLists");
585       }
586       public void onFailure(final String message) {
587         WebServiceError("GetInstanceLists", "Failed to get up to date
    instance lists.");
588       }
589     };
590
591     postCommandToGameServer(GET_INSTANCE_LISTS_COMMAND,
592         Lists.<NameValuePair>newArrayList(
593             new BasicNameValuePair(GAME_ID_KEY, GameId()),
594             new BasicNameValuePair(INSTANCE_ID_KEY, InstanceId()),
595             new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()))
    ,
596         readMessagesCallback);
597   }
598
599   private void processInstanceLists(JSONObject instanceLists){
600     try {
601       joinedInstances = JsonUtil.getStringListFromJsonArray(
    instanceLists.
602           getJSONArray(JOINED_LIST_KEY));
603
604       publicInstances = JsonUtil.getStringListFromJsonArray(
    instanceLists.
605           getJSONArray(PUBLIC_LIST_KEY));
606
607       List<String> receivedInstancesInvited = JsonUtil.
    getStringListFromJsonArray(instanceLists.
608           getJSONArray(INVITED_LIST_KEY));
609
610       if (!receivedInstancesInvited.equals(InvitedInstances())) {
611         List<String> oldList = invitedInstances;
612         invitedInstances = receivedInstancesInvited;
613         List<String> newInvites = new ArrayList<String>(
    receivedInstancesInvited);
614         newInvites.removeAll(oldList);
615
616         for (final String instanceInvited : newInvites) {
617           Invited(instanceInvited);
618         }
619       }
620
621     } catch (JSONException e) {
622       Log.w(LOG_TAG, e);
623       Info("Instance lists failed to parse.");
624     }
625   }
626
627   /**
628    * Retrieves messages of the specified type.
629    *
630    * Requests that only messages which have not been seen during
```

```
631     * the current session are returned. Messages will be processed
632     * in chronological order with the oldest first, however, only
633     * the count newest messages will be retrieved. This means that
634     * one could "miss out" on some messages if they request less than
635     * the number of messages created since the last request for
636     * that message type.
637     *
638     * Setting type to the empty string will fetch all message types.
639     * Even though those message types were not specifically requested,
640     * their most recent message time will be updated. This keeps
641     * players from receiving the same message again if they later
642     * request the specific message type.
643     *
644     * Note that the message receive times are not updated until after
645     * the messages are actually received. Thus, if multiple message
646     * requests are made before the previous ones return, they could
647     * send stale time values and thus receive the same messages more
648     * than once. To avoid this, application creators should wait for
649     * the get messages function to return before calling it again.
650     *
651     * @param type The type of message to retrieve. If the empty string
652     * is used as the message type then all message types will be
653     * requested.
654     * @param count The maximum number of messages to retrieve. This
655     * should be an integer from 1 to 1000.
656     */
657    @SimpleFunction(
658        description = "Retrieves messages of the specified type.")
659    public void GetMessages(final String type, final int count) {
660      AsynchUtil.runAsynchronously(new Runnable() {
661        public void run() { postGetMessages(type, count); }});
662    }
663
664    private void postGetMessages(final String requestedType, final int
       count) {
665      AsyncCallbackPair<JSONObject> myCallback = new AsyncCallbackPair<
       JSONObject>() {
666        public void onSuccess(final JSONObject result) {
667          try {
668            int count = result.getInt(COUNT_KEY);
669            JSONArray messages = result.getJSONArray(MESSAGES_LIST_KEY);
670            for (int i = 0; i < count; i++) {
671              JSONObject message = messages.getJSONObject(i);
672              String type = message.getString(TYPE_KEY);
673              String sender = message.getString(MESSAGE_SENDER_KEY);
674              String time = message.getString(MESSAGE_TIME_KEY);
675              List<Object> contents = JsonUtil.getListFromJsonArray(
       message.
676                  getJSONArray(MESSAGE_CONTENT_KEY));
677              // Assumes that the server is going to return messages in
678              // chronological order.
679              if (requestedType.equals("")) {
680                instance.putMessageTime(requestedType, time);
681              }
```

```
682             instance.putMessageTime(type, time);
683             GotMessage(type, sender, contents);
684           }
685         } catch (JSONException e) {
686           Log.w(LOG_TAG, e);
687           Info("Failed to parse messages response.");
688         }
689         FunctionCompleted("GetMessages");
690       }
691
692       public void onFailure(String message) {
693         WebServiceError("GetMessages", message);
694       }
695     };
696
697     if (InstanceId().equals("")) {
698       Info("You must join an instance before attempting to fetch
      messages.");
699       return;
700     }
701
702     postCommandToGameServer(GET_MESSAGES_COMMAND,
703         Lists.<NameValuePair>newArrayList(
704             new BasicNameValuePair(GAME_ID_KEY, GameId()),
705             new BasicNameValuePair(INSTANCE_ID_KEY, InstanceId()),
706             new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()),
707             new BasicNameValuePair(COUNT_KEY, new Integer(count).
      toString()),
708             new BasicNameValuePair(MESSAGE_TIME_KEY, instance.
      getMessageTime(requestedType)),
709             new BasicNameValuePair(TYPE_KEY, requestedType)),
710         myCallback);
711   }
712
713   /**
714    * Invites a player to this game instance.
715    *
716    * Players implicitly accept invitations when they join games by
717    * setting the instance id in their GameClient.
718    *
719    * Invitations remain active as long as the game instance exists.
720    *
721    * @param playerEmail a string containing the email address of the
722    * player to become leader. The email should be in one of the
723    * following formats:<br>"Name O. Person
724    * &ltname.o.person@gmail.com&gt"<br>"name.o.person@gmail.com".
725    */
726   @SimpleFunction(
727       description = "Invites a player to this game instance.")
728   public void Invite(final String playerEmail) {
729     AsynchUtil.runAsynchronously(new Runnable() {
730       public void run() { postInvite(playerEmail); }});
731   }
732
```

```
733   private void postInvite(final String inviteeEmail) {
734     AsyncCallbackPair<JSONObject> inviteCallback = new
      AsyncCallbackPair<JSONObject>(){
735       public void onSuccess(final JSONObject response) {
736         try {
737           String invitedPlayer = response.getString(INVITEE_KEY);
738
739           if (invitedPlayer.equals("")) {
740             Info(invitedPlayer + " was already invited.");
741           } else {
742             Info("Successfully invited " + invitedPlayer + ".");
743           }
744         } catch (JSONException e) {
745           Log.w(LOG_TAG, e);
746           Info("Failed to parse invite player response.");
747         }
748         FunctionCompleted("Invite");
749       }
750       public void onFailure(final String message) {
751         WebServiceError("Invite", message);
752       }
753     };
754
755     if (InstanceId().equals("")) {
756       Info("You must have joined an instance before you can invite new
      players.");
757       return;
758     }
759
760     postCommandToGameServer(INVITE_COMMAND,
761         Lists.<NameValuePair>newArrayList(
762             new BasicNameValuePair(GAME_ID_KEY, GameId()),
763             new BasicNameValuePair(INSTANCE_ID_KEY, InstanceId()),
764             new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()),
765             new BasicNameValuePair(INVITEE_KEY, inviteeEmail)),
766         inviteCallback);
767   }
768
769   /**
770    * Requests to leave the current instance. If the player is the
771    * current leader, the lead will be passed to another player.
772    *
773    * If there are no other players left in the instance after the
774    * current player leaves, the instance will become unjoinable.
775    *
776    * Upon successful completion of this command, the instance
777    * lists will be updated and InstanceId will be set back to the
778    * empty string.
779    *
780    * Note that while this call does clear the leader and player
781    * lists, no NewLeader or PlayerLeft events are raised.
782    */
783   @SimpleFunction(description = "Leaves the current instance.")
784   public void LeaveInstance() {
```

```
785       AsynchUtil.runAsynchronously(new Runnable() {
786         public void run() {
787           postLeaveInstance();
788         }
789       });
790     }
791
792     private void postLeaveInstance() {
793       AsyncCallbackPair<JSONObject> setInstanceCallback = new
          AsyncCallbackPair<JSONObject>(){
794         public void onSuccess(final JSONObject response) {
795           SetInstance("");
796           processInstanceLists(response);
797           FunctionCompleted("LeaveInstance");
798         }
799         public void onFailure(final String message) {
800           WebServiceError("LeaveInstance", message);
801         }
802       };
803
804       postCommandToGameServer(LEAVE_INSTANCE_COMMAND,
805           Lists.<NameValuePair>newArrayList(
806               new BasicNameValuePair(GAME_ID_KEY, GameId()),
807               new BasicNameValuePair(INSTANCE_ID_KEY, InstanceId()),
808               new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()))
          ,
809               setInstanceCallback);
810     }
811
812     /**
813      * Creates a new game instance.  The instance has a unique
814      * instanceId, and the leader is the player who created it. The
815      * player that creates the game automatically joins it without
816      * being sent an invitation.
817      *
818      * The actual instance id could differ from the instanceId
819      * specified because the game server will enforce uniqueness. The
820      * actual instanceId will be provided to AppInventor when a
821      * NewInstanceMade event triggers upon successful completion of
822      * this server request.
823      *
824      * @param instanceId A string to use as for the instance
825      * id. If no other instance exists with this id, the new instance
826      * will have this id. However, since the id must be unique, if
827      * another instance exists with the same one, then a number
828      * will be appended to the end of this prefix.
829      * @param makePublic A boolean indicating whether or not the
830      * instance should be publicly viewable and able to be joined by
831      * anyone.
832      */
833     @SimpleFunction(description = "Asks the server to create a new " +
834         "instance of this game.")
835     public void MakeNewInstance(final String instanceId, final boolean
          makePublic) {
```

```
836       AsynchUtil.runAsynchronously(new Runnable() {
837         public void run() { postMakeNewInstance(instanceId, makePublic);
          }});
838     }
839
840     private void postMakeNewInstance(final String requestedInstanceId,
          final Boolean makePublic) {
841       AsyncCallbackPair<JSONObject> makeNewGameCallback = new
          AsyncCallbackPair<JSONObject>(){
842         public void onSuccess(final JSONObject response) {
843           processInstanceLists(response);
844           NewInstanceMade(InstanceId());
845           FunctionCompleted("MakeNewInstance");
846         }
847         public void onFailure(final String message) {
848           WebServiceError("MakeNewInstance", message);
849         }
850       };
851
852       postCommandToGameServer(NEW_INSTANCE_COMMAND,
853           Lists.<NameValuePair>newArrayList(
854               new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()),
855               new BasicNameValuePair(GAME_ID_KEY, GameId()),
856               new BasicNameValuePair(INSTANCE_ID_KEY,
          requestedInstanceId),
857               new BasicNameValuePair(INSTANCE_PUBLIC_KEY, makePublic.
          toString())),
858               makeNewGameCallback, true);
859     }
860
861     /**
862      * Creates a new message and sends it to the stated recipients.
863      *
864      * @param type A "key" for the message. This identifies the type of
865      * message so that when other players receive the message they know
866      * how to properly handle it.
867      * @param recipients If set to an empty list, the server will send
868      * this message with a blank set of recipients, meaning that all
869      * players in the instance are able to retrieve it. To limit the
870      * message receipt to a single person or a group of people,
871      * recipients should be a list of the email addresses of the people
872      * meant to receive the message. Each email should be in one of the
873      * following formats:<br>
874      * "Name O. Person &ltname.o.person@gmail.com&gt"<br>
875      * "name.o.person@gmail.com"
876      * @param contents the contents of the message. This can be any
877      * AppInventor data value.
878      */
879     @SimpleFunction(description = "Sends a keyed message to all " +
880         "recipients in the recipients list. The message will " +
881         "consist of the contents list.")
882     public void SendMessage(final String type, final YailList recipients
          , final YailList contents) {
883       AsynchUtil.runAsynchronously(new Runnable() {
```

```
884         public void run() { postNewMessage(type, recipients, contents);
        }});
885     }
886
887     private void postNewMessage(final String type, YailList recipients,
        YailList contents){
888       AsyncCallbackPair<JSONObject> myCallback = new AsyncCallbackPair<
        JSONObject>(){
889         public void onSuccess(final JSONObject response) {
890           FunctionCompleted("SendMessage");
891         }
892         public void onFailure(final String message) {
893           WebServiceError("SendMessage", message);
894         }
895       };
896
897       if (InstanceId().equals("")) {
898         Info("You must have joined an instance before you can send
        messages.");
899         return;
900       }
901
902       postCommandToGameServer(NEW_MESSAGE_COMMAND,
903           Lists.<NameValuePair>newArrayList(
904               new BasicNameValuePair(GAME_ID_KEY, GameId()),
905               new BasicNameValuePair(INSTANCE_ID_KEY, InstanceId()),
906               new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()),
907               new BasicNameValuePair(TYPE_KEY, type),
908               new BasicNameValuePair(MESSAGE_RECIPIENTS_KEY, recipients.
        toJSONString()),
909               new BasicNameValuePair(MESSAGE_CONTENT_KEY, contents.
        toJSONString()),
910               new BasicNameValuePair(MESSAGE_TIME_KEY, instance.
        getMessageTime(type))),
911           myCallback);
912     }
913
914     /**
915      * Submits a command to the game server. Server commands are
916      * custom actions that are performed on the server. The arguments
917      * required and return value of a server command depend on its
918      * implementation.
919      *
920      * For more information about server commands, consult the game
921      * server code at:
922      * http://code.google.com/p/app-inventor-for-android/
923      *
924      * @param command The name of the server command.
925      * @param arguments The arguments to pass to the server to specify
926      * how to execute the command.
927      */
928     @SimpleFunction(description = "Sends the specified command to " +
929         "the game server.")
```

```
930   public void ServerCommand(final String command, final YailList
       arguments) {
931     AsynchUtil.runAsynchronously(new Runnable() {
932       public void run() { postServerCommand(command, arguments); }});
933   }
934
935   private void postServerCommand(final String command, final YailList
       arguments){
936     AsyncCallbackPair<JSONObject> myCallback = new AsyncCallbackPair<
       JSONObject>() {
937       public void onSuccess(final JSONObject result) {
938         try {
939           ServerCommandSuccess(command, JsonUtil.getListFromJsonArray(
       result.
940               getJSONArray(MESSAGE_CONTENT_KEY)));
941         } catch (JSONException e) {
942           Log.w(LOG_TAG, e);
943           Info("Server command response failed to parse.");
944         }
945         FunctionCompleted("ServerCommand");
946       }
947
948       public void onFailure(String message) {
949         ServerCommandFailure(command, arguments);
950         WebServiceError("ServerCommand", message);
951       }
952     };
953
954     Log.d(LOG_TAG, "Going to post " + command + " with args " +
       arguments);
955     postCommandToGameServer(SERVER_COMMAND,
956         Lists.<NameValuePair>newArrayList(
957             new BasicNameValuePair(GAME_ID_KEY, GameId()),
958             new BasicNameValuePair(INSTANCE_ID_KEY, InstanceId()),
959             new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()),
960             new BasicNameValuePair(COMMAND_TYPE_KEY, command),
961             new BasicNameValuePair(COMMAND_ARGUMENTS_KEY, arguments.
       toJSONString())),
962         myCallback);
963   }
964
965   /**
966    * Specifies the game instance id.  Taken together, the game ID and
967    * the instance ID uniquely identify the game.
968    *
969    * @param instanceId the name of the game instance to join.
970    */
971   @SimpleFunction(description = "Sets InstanceId and joins the " +
972       "specified instance.")
973   public void SetInstance(final String instanceId) {
974     AsynchUtil.runAsynchronously(new Runnable() {
975       public void run() {
976         if (instanceId.equals("")) {
977           Log.d(LOG_TAG, "Instance id set to empty string.");
```

```
978           if (!InstanceId().equals("")) {
979             instance = new GameInstance("");
980             InstanceIdChanged("");
981             FunctionCompleted("SetInstance");
982           }
983         } else {
984           postSetInstance(instanceId);
985         }
986       }
987     });
988   }
989
990   private void postSetInstance(String instanceId) {
991     AsyncCallbackPair<JSONObject> setInstanceCallback = new
      AsyncCallbackPair<JSONObject>(){
992       public void onSuccess(final JSONObject response) {
993         processInstanceLists(response);
994         FunctionCompleted("SetInstance");
995       }
996       public void onFailure(final String message) {
997         WebServiceError("SetInstance", message);
998       }
999     };
1000
1001    postCommandToGameServer(JOIN_INSTANCE_COMMAND,
1002        Lists.<NameValuePair>newArrayList(
1003            new BasicNameValuePair(GAME_ID_KEY, GameId()),
1004            new BasicNameValuePair(INSTANCE_ID_KEY, instanceId),
1005            new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()))
      ,
1006            setInstanceCallback, true);
1007  }
1008
1009  /**
1010   * Specifies the game's leader. At any time, each game instance
1011   * has only one leader, but the leader may change over time.
1012   * Initially, the leader is the game instance creator. Application
1013   * inventors determine special properties of the leader.
1014   *
1015   * The leader can only be set by the current leader of the game.
1016   *
1017   * @param playerEmail a string containing the email address of the
1018   * player to become leader. The email should be in one of the
1019   * following formats:
1020   * <br>"Name O. Person &ltname.o.person@gmail.com&gt"
1021   * <br>"name.o.person@gmail.com".
1022   */
1023  @SimpleFunction(description = "Tells the server to set the " +
1024      "leader to playerId. Only the current leader may " +
1025      "successfully set a new leader.")
1026  public void SetLeader(final String playerEmail) {
1027    AsynchUtil.runAsynchronously(new Runnable() {
1028      public void run() { postSetLeader(playerEmail); }});
1029  }
```

```
1030
1031    private void postSetLeader(final String newLeader) {
1032      AsyncCallbackPair<JSONObject> setLeaderCallback = new
        AsyncCallbackPair<JSONObject>(){
1033        public void onSuccess(final JSONObject response) {
1034          FunctionCompleted("SetLeader");
1035        }
1036        public void onFailure(final String message) {
1037          WebServiceError("SetLeader", message);
1038        }
1039      };
1040
1041      if (InstanceId().equals("")) {
1042        Info("You must join an instance before attempting to set a
        leader.");
1043        return;
1044      }
1045
1046      postCommandToGameServer(SET_LEADER_COMMAND,
1047          Lists.<NameValuePair>newArrayList(
1048              new BasicNameValuePair(GAME_ID_KEY, GameId()),
1049              new BasicNameValuePair(INSTANCE_ID_KEY, InstanceId()),
1050              new BasicNameValuePair(PLAYER_ID_KEY, UserEmailAddress()),
1051              new BasicNameValuePair(LEADER_KEY, newLeader)),
1052              setLeaderCallback);
1053    }
1054
1055    //--------------------------------------------------------------------
1056    // Activity Lifecycle Management
1057
1058    /**
1059     * Called automatically by the operating system.
1060     *
1061     * Currently does nothing.
1062     */
1063    public void onResume() {
1064      Log.d(LOG_TAG, "Activity Resumed.");
1065    }
1066
1067    /**
1068     * Called automatically by the operating system.
1069     *
1070     * Currently does nothing.
1071     */
1072    public void onStop() {
1073      Log.d(LOG_TAG, "Activity Stopped.");
1074    }
1075
1076    //--------------------------------------------------------------------
1077    // Utility Methods
1078
1079    private void postCommandToGameServer(final String commandName,
1080        List<NameValuePair> params, final AsyncCallbackPair<JSONObject>
        callback) {
```

```
1081      postCommandToGameServer(commandName, params, callback, false);
1082    }
1083
1084    private void postCommandToGameServer(final String commandName,
1085        final List<NameValuePair> params, final AsyncCallbackPair<
          JSONObject> callback,
1086        final boolean allowInstanceIdChange) {
1087      AsyncCallbackPair<JSONObject> thisCallback = new AsyncCallbackPair
          <JSONObject>() {
1088        public void onSuccess(JSONObject responseObject) {
1089          Log.d(LOG_TAG, "Received response for " + commandName + ": " +
           responseObject.toString());
1090
1091          try {
1092            if (responseObject.getBoolean(ERROR_RESPONSE_KEY)) {
1093              callback.onFailure(responseObject.getString(
          SERVER_RETURN_VALUE_KEY));
1094            } else {
1095              String responseGameId = responseObject.getString(
          GAME_ID_KEY);
1096              if (!responseGameId.equals(GameId())) {
1097                Info("Incorrect game id in response: + " +
          responseGameId + ".");
1098                return;
1099              }
1100              String responseInstanceId = responseObject.getString(
          INSTANCE_ID_KEY);
1101              if (responseInstanceId.equals("")) {
1102                callback.onSuccess(responseObject.getJSONObject(
          SERVER_RETURN_VALUE_KEY));
1103                return;
1104              }
1105
1106              if (responseInstanceId.equals(InstanceId())) {
1107                updateInstanceInfo(responseObject);
1108              } else {
1109                if (allowInstanceIdChange || InstanceId().equals("")) {
1110                  instance = new GameInstance(responseInstanceId);
1111                  updateInstanceInfo(responseObject);
1112                  InstanceIdChanged(responseInstanceId);
1113                } else {
1114                  Info("Ignored server response to " + commandName + "
          for incorrect instance " +
1115                      responseInstanceId + ".");
1116                  return;
1117                }
1118              }
1119              callback.onSuccess(responseObject.getJSONObject(
          SERVER_RETURN_VALUE_KEY));
1120            }
1121          } catch (JSONException e) {
1122            Log.w(LOG_TAG, e);
1123            callback.onFailure("Failed to parse JSON response to command
           " + commandName);
```

```
1124          }
1125        }
1126        public void onFailure(String failureMessage) {
1127          Log.d(LOG_TAG, "Posting to server failed for " + commandName +
        " with arguments " +
1128              params + "\n Failure message: " +  failureMessage);
1129          callback.onFailure(failureMessage);
1130        }
1131      };
1132
1133      WebServiceUtil.getInstance().postCommandReturningObject(ServiceUrl
        (), commandName, params,
1134          thisCallback);
1135    }
1136
1137    private void updateInstanceInfo(JSONObject responseObject) throws
        JSONException {
1138      boolean newLeader = false;
1139      String leader = responseObject.getString(LEADER_KEY);
1140      List<String> receivedPlayers = JsonUtil.getStringListFromJsonArray
        (responseObject.
1141          getJSONArray(PLAYERS_LIST_KEY));
1142
1143      if (!Leader().equals(leader)) {
1144        instance.setLeader(leader);
1145        newLeader = true;
1146      }
1147
1148      PlayerListDelta playersDelta = instance.setPlayers(receivedPlayers
        );
1149      if (playersDelta != PlayerListDelta.NO_CHANGE) {
1150        for (final String player : playersDelta.getPlayersRemoved()) {
1151          PlayerLeft(player);
1152        }
1153        for (final String player : playersDelta.getPlayersAdded()) {
1154          PlayerJoined(player);
1155        }
1156      }
1157
1158      if (newLeader) {
1159        NewLeader(Leader());
1160      }
1161    }
1162  }
```

B.2: GameInstance.java - A container for information pertaining to game instances.

```
1  // Copyright 2009 Google Inc. All Rights Reserved.
2
3  package com.google.devtools.simple.runtime.components.android.util;
4
5  import java.util.ArrayList;
6  import java.util.HashMap;
```

```
7  import java.util.List;
8  import java.util.Map;
9
10 /**
11  * A container for information about a GameInstance for use
12  * with the App Inventor game framework.
13  *
14  * @author billmag@google.com (Bill Magnuson)
15  *
16  */
17 public class GameInstance {
18   private String instanceId;
19   private String leader;
20
21   // players in the current game
22   private List<String> players;
23
24   // Use this to store the most recent time stamp of each message type
       received.
25   private Map<String, String> messageTimes;
26
27
28   /**
29    * A GameInstance contains the most recent values
30    * for the leader and players of a particular game instance.
31    *
32    * This object is also used to keep track of the most recent
33    * time that a particular message type was retrieved from the
34    * server.
35    *
36    * @param instanceId The unique String that identifies this
37    * instance.
38    */
39   public GameInstance(String instanceId) {
40     players = new ArrayList<String>(0);
41     messageTimes = new HashMap<String, String>();
42     this.instanceId = instanceId;
43     this.leader = "";
44   }
45
46   /**
47    * Return the instance id of this instance.
48    * @return the instance id.
49    */
50   public String getInstanceId() {
51     return instanceId;
52   }
53
54   /**
55    * Return the current leader of this instance.
56    * @return The email address of the current leader.
57    */
58   public String getLeader() {
59     return leader;
```

```
60    }
61
62    /**
63     * Sets the leader of this instance.
64     * @param leader The email address of the new leader.
65     */
66    public void setLeader(String leader) {
67      this.leader = leader;
68    }
69
70    /**
71     * Sets the players of this instances to currentPlayersList.
72     *
73     * Compares the current players list with the new one and returns
74     * a delta to the caller.
75     *
76     * @param newPlayersList All players currently in the instance.
77     * @return PlayersListDelta.NO_CHANGE if there is no change in
78     * membership. Otherwise returns a PlayersListDelta with the
79     * appropriate player lists.
80     */
81    public PlayerListDelta setPlayers(List<String> newPlayersList) {
82      if (newPlayersList.equals(players)) {
83        return PlayerListDelta.NO_CHANGE;
84      }
85      List<String> removed = players;
86      List<String> added = new ArrayList<String>(newPlayersList);
87      players = new ArrayList<String>(newPlayersList);
88
89      added.removeAll(removed);
90      removed.removeAll(newPlayersList);
91      // This happens if the players list is the same but the ordering
92      // has changed for some reason.
93      if (added.size() == 0 && removed.size() == 0) {
94        return PlayerListDelta.NO_CHANGE;
95      }
96
97      return new PlayerListDelta(removed, added);
98    }
99
100   /**
101    * Return the list of players currently in this instance.
102    *
103    * @return A list of the players in the instance.
104    */
105   public List<String> getPlayers() {
106     return players;
107   }
108
109   /**
110    * Return the most recently put time string for this type.
111    *
112    * This should represent the creation time of the most
113    * recently received message of the specified type and can
```

```
114     * be used to filter available messages to find those that
115     * have not been received.
116     *
117     * @param type The message type.
118     * @return The most recently put value for this type.
119     */
120    public String getMessageTime(String type) {
121      if (messageTimes.containsKey(type)) {
122        return messageTimes.get(type);
123      }
124      return "";
125    }
126
127    /**
128     * Puts a new time string for the specified message type.
129     *
130     * The string should be some value that can be understood
131     * by its eventual consumer. It is left as a string here
132     * to remove the need to convert back and forth from DateTime
133     * objects when dealing with web services.
134     *
135     * @param type The message type.
136     * @param time A string representing the time the message
137     * was created.
138     */
139    public void putMessageTime(String type, String time) {
140      messageTimes.put(type, time);
141    }
142  }
```

B.2 Utilities and Data Structures

B.3: YailList.java - The App Inventor collection primitive.

```
1  // Copyright 2009 Google Inc. All Rights Reserved.
2
3  package com.google.devtools.simple.runtime.components.util;
4
5  import com.google.devtools.simple.runtime.errors.YailRuntimeError;
6
7  import java.util.List;
8  import java.util.Collection;
9
10 import gnu.lists.FString;
11 import gnu.lists.LList;
12 import gnu.lists.Pair;
13
14 import org.json.JSONException;
15 import org.json.JSONObject;
16
17 /**
```

```
18   * The YailList is a wrapper around the gnu.list.Pair class used
19   * by the Kawa framework. YailList is the main list primitive used
20   * by App Inventor components.
21   *
22   * @author gleitz@google.com (Benjamin Gleitzman)
23   * @author billmag@google.com (Bill Magnuson)
24   */
25  public class YailList extends Pair {
26
27    // Component writers take note!
28    // If you want to pass back a list to the blocks language, the
29    // straightforward way to do this is simply to pass
30    // back an ArrayList.  If you construct a YailList to return
31    // to codeblocks, you must guarantee that the elements of the list
32    // are "sanitized".  That is, you must pass back a tree whose
33    // subtrees are themselves YailLists, and whose leaves are all
34    // legitimate Yail data types.  See the definition of sanitization
35    // in runtime.scm.
36
37    /**
38     * Create an empty YailList.
39     */
40    public YailList() {
41      super(YailConstants.YAIL_HEADER, LList.Empty);
42    }
43
44    private YailList(Object cdrval) {
45      super(YailConstants.YAIL_HEADER, cdrval);
46    }
47
48    /**
49     * Create a YailList from an array.
50     */
51    public static YailList makeList(Object[] objects) {
52      LList newCdr = Pair.makeList(objects, 0);
53      return new YailList(newCdr);
54    }
55
56    /**
57     * Create a YailList from a List.
58     */
59    public static YailList makeList(List vals) {
60      LList newCdr = Pair.makeList(vals);
61      return new YailList(newCdr);
62    }
63
64    /**
65     * Create a YailList from a Collection.
66     */
67    public static YailList makeList(Collection vals) {
68      LList newCdr = Pair.makeList(vals.toArray(), 0);
69      return new YailList(newCdr);
70    }
71
```

```
72    /**
73     * Return this YailList as an array.
74     */
75    @Override
76    public Object[] toArray() {
77      if (cdr instanceof Pair) {
78        return ((Pair) cdr).toArray();
79      } else if (cdr instanceof LList) {
80        return ((LList) cdr).toArray();
81      } else {
82        throw new YailRuntimeError("YailList cannot be represented as an
      array", "YailList Error.");
83      }
84    }
85
86    /**
87     * Return this YailList as an array of Strings.
88     */
89    public String[] toStringArray() {
90      int size = this.size();
91      String[] objects = new String[size];
92      for (int i = 1; i <= size; i++) {
93        objects[i - 1] = String.valueOf(get(i));
94      }
95      return objects;
96    }
97
98    /**
99     * Return a strictly syntactically correct JSON text
100    * representation of this YailList. Only supports String, Number,
101    * Boolean, YailList, FString and arrays containing these types.
102    */
103   public String toJSONString() {
104     try {
105       StringBuilder json = new StringBuilder();
106       String separator = "";
107       json.append('[');
108       int size = this.size();
109       for (int i = 1; i <= size; i++) {
110         Object value = get(i);
111         json.append(separator).append(getJsonRepresentation(value));
112         separator = ",";
113       }
114       json.append(']');
115
116       return json.toString();
117
118     } catch (JSONException e) {
119       throw new YailRuntimeError("List failed to convert to JSON.", "
      JSON Creation Error.");
120     }
121   }
122
123   /**
```

```
124     * Return the size of this YailList.
125     */
126    @Override
127    public int size() {
128      return super.size() - 1;
129    }
130
131    /**
132     * Return a String representation of this YailList.
133     */
134    @Override
135    public String toString() {
136      if (cdr instanceof Pair) {
137        return ((Pair) cdr).toString();
138      } else if (cdr instanceof LList) {
139        return ((LList) cdr).toString();
140      } else {
141        throw new RuntimeException("YailList cannot be represented as a
       String");
142      }
143    }
144
145    /**
146     * Return the String at the given index.
147     */
148    public String getString(int index) {
149      return (String) get(index + 1);
150    }
151
152    private String getJsonRepresentation(Object value) throws
       JSONException {
153      if (value == null || value.equals(null)) {
154        return "null";
155      }
156      if (value instanceof FString) {
157        return JSONObject.quote(value.toString());
158      }
159      if (value instanceof YailList) {
160        return ((YailList) value).toJSONString();
161      }
162      if (value instanceof Number) {
163        return JSONObject.numberToString((Number) value);
164      }
165      if (value instanceof Boolean) {
166        return value.toString();
167      }
168      if (value.getClass().isArray()) {
169        StringBuilder sb = new StringBuilder();
170        sb.append("[");
171        String separator = "";
172        for (Object o: (Object[]) value) {
173          sb.append(separator).append(getJsonRepresentation(o));
174          separator = ",";
175        }
```

```
176         sb.append("]");
177         return sb.toString();
178       }
179       return JSONObject.quote(value.toString());
180     }
181
182
183 }
```

B.4: JsonUtil.java - Utility functions for converting JSON to data representations understood by App Inventor.

```
1  // Copyright 2010 Google Inc. All Rights Reserved.
2
3  package com.google.devtools.simple.runtime.components.util;
4
5  import org.json.JSONArray;
6  import org.json.JSONException;
7  import org.json.JSONObject;
8
9  import java.util.ArrayList;
10 import java.util.Collections;
11 import java.util.Iterator;
12 import java.util.List;
13
14 /**
15  * Provides utility functions to create Java collections out of
16  * JSON.
17  *
18  * @author billmag@google.com (Bill Magnuson)
19  *
20  */
21 public class JsonUtil {
22
23   /**
24    * Prevent instantiation.
25    */
26   private JsonUtil() {
27   }
28
29   /**
30    * Returns a list of String objects from a JSONArray. This
31    * does not do any kind of recursive unpacking of the array.
32    * Thus, if the array includes other JSON arrays or JSON objects
33    * their string representation will be a single item in the
34    * returned list.
35    *
36    * @param jArray The JSONArray to convert.
37    * @return A List of the String representation of each item in
38    * the JSON array.
39    * @throws JSONException if an element of jArray cannot be
40    * converted to a String.
```

```
41      */
42     public static List<String> getStringListFromJsonArray(JSONArray
         jArray) throws JSONException {
43       List<String> returnList = new ArrayList<String>();
44       for (int i = 0; i < jArray.length(); i++) {
45         String val = jArray.getString(i);
46         returnList.add(val);
47       }
48       return returnList;
49     }
50
51     /**
52      * Returns a Java Object list of a JSONArray with each item in
53      * the array converted using convertJsonItem().
54      *
55      * @param jArray The JSONArray to convert.
56      * @return A List of Strings and more Object lists.
57      * @throws JSONException if an element in jArray cannot be
58      * converted properly.
59      */
60     public static List<Object> getListFromJsonArray(JSONArray jArray)
         throws JSONException {
61       List<Object> returnList = new ArrayList<Object>();
62       for (int i = 0; i < jArray.length(); i++) {
63         returnList.add(convertJsonItem(jArray.get(i)));
64       }
65       return returnList;
66     }
67
68     /**
69      * Returns a list containing one two item list per key in jObject.
70      * Each two item list has the key String as its first element and
71      * the result of calling convertJsonItem() on its value as the
72      * second element. The sub-lists in the returned list will appear
73      * in alphabetical order by key.
74      *
75      * @param jObject The JSONObject to convert.
76      * @return A list of two item lists: [String key, Object value].
77      * @throws JSONException if an element in jObject cannot be
78      * converted properly.
79      */
80     public static List<Object> getListFromJsonObject(JSONObject jObject)
         throws JSONException {
81       List<Object> returnList = new ArrayList<Object>();
82       Iterator<String> keys = jObject.keys();
83
84       List<String> keysList = new ArrayList<String>();
85       while (keys.hasNext()) {
86         keysList.add(keys.next());
87       }
88       Collections.sort(keysList);
89
90       for (String key : keysList) {
91         List<Object> nestedList = new ArrayList<Object>();
```

```
92          nestedList.add(key);
93          nestedList.add(convertJsonItem(jObject.get(key)));
94          returnList.add(nestedList);
95        }
96
97        return returnList;
98      }
99
100     /**
101      * Returns a Java object representation of objects that are
102      * encountered inside of JSON created using the org.json package.
103      * JSON arrays and objects are transformed into their list
104      * representations using getListFromJsonArray and
105      * getListFromJsonObject respectively.
106      *
107      * Java Boolean values and the Strings "true" and "false" (case
108      * insensitive) are inserted as Booleans. Java Numbers are
109      * inserted without modification and all other values are inserted
110      * as their toString(). value.
111      *
112      * @param o An item in a JSON array or JSON object to convert.
113      * @return A Java Object representing o or the String "null"
114      * if o is null.
115      * @throws JSONException if o fails to parse.
116      */
117     public static Object convertJsonItem(Object o) throws JSONException
        {
118       if (o == null) {
119         return "null";
120       }
121
122       if (o instanceof JSONObject) {
123         return getListFromJsonObject((JSONObject) o);
124       }
125
126       if (o instanceof JSONArray) {
127         return getListFromJsonArray((JSONArray) o);
128       }
129
130       if (o.equals(Boolean.FALSE) || (o instanceof String &&
131           ((String) o).equalsIgnoreCase("false"))) {
132         return false;
133       }
134
135       if (o.equals(Boolean.TRUE) || (o instanceof String && ((String) o)
        .equalsIgnoreCase("true"))) {
136         return true;
137       }
138
139       if (o instanceof Number) {
140         return o;
141       }
142
143       return o.toString();
```

```
144     }
145 }
```

B.5: WebServiceUtil.java - Utility functions for making POST commands from Android applications.

```
1  // Copyright 2009 Google Inc. All Rights Reserved.
2
3  package com.google.devtools.simple.runtime.components.android.util;
4
5  import android.util.Log;
6
7  import org.apache.http.NameValuePair;
8  import org.apache.http.client.ClientProtocolException;
9  import org.apache.http.client.HttpClient;
10 import org.apache.http.client.ResponseHandler;
11 import org.apache.http.client.entity.UrlEncodedFormEntity;
12 import org.apache.http.client.methods.HttpPost;
13 import org.apache.http.conn.params.ConnManagerParams;
14 import org.apache.http.conn.scheme.PlainSocketFactory;
15 import org.apache.http.conn.scheme.Scheme;
16 import org.apache.http.conn.scheme.SchemeRegistry;
17 import org.apache.http.conn.ssl.SSLSocketFactory;
18 import org.apache.http.impl.client.BasicResponseHandler;
19 import org.apache.http.impl.client.DefaultHttpClient;
20 import org.apache.http.impl.conn.tsccm.ThreadSafeClientConnManager;
21 import org.apache.http.params.BasicHttpParams;
22 import org.apache.http.params.HttpConnectionParams;
23 import org.apache.http.protocol.HTTP;
24 import org.json.JSONArray;
25 import org.json.JSONException;
26 import org.json.JSONObject;
27
28 import java.io.IOException;
29 import java.io.UnsupportedEncodingException;
30 import java.util.ArrayList;
31 import java.util.List;
32
33 /**
34  * These commands post to the Web and get responses that are assumed
35  * to be JSON structures: a string, a JSON array, or a JSON object.
36  * It's up to the caller of these routines to decide which version
37  * to use, and to decode the response.
38  *
39  * @author halabelson@google.com (Hal Abelson)
40  * @autho billmag@google.com (Bill Magnuson)
41  */
42 public class WebServiceUtil {
43
44   private static final WebServiceUtil INSTANCE = new WebServiceUtil();
45   private static final String LOG_TAG = "WebServiceUtil";
46   private static HttpClient httpClient = null;
```

```
47  private static Object httpClientSynchronizer = new Object();
48
49  private WebServiceUtil(){
50  }
51
52  /**
53   * Returns the one <code>WebServiceUtil</code> instance
54   * @return the one <code>WebServiceUtil</code> instance
55   */
56  public static WebServiceUtil getInstance() {
57    // This needs to be here instead of in the constructor because
58    // it uses classes that are in the AndroidSDK and thus would
59    // cause Stub! errors when running the component descriptor.
60    synchronized(httpClientSynchronizer) {
61      if (httpClient == null) {
62        SchemeRegistry schemeRegistry = new SchemeRegistry();
63        schemeRegistry.register(new Scheme("http", PlainSocketFactory.
    getSocketFactory(), 80));
64        schemeRegistry.register(new Scheme("https", SSLSocketFactory.
    getSocketFactory(), 443));
65        BasicHttpParams params = new BasicHttpParams();
66        HttpConnectionParams.setConnectionTimeout(params, 20 * 1000);
67        HttpConnectionParams.setSoTimeout(params, 20 * 1000);
68        ConnManagerParams.setMaxTotalConnections(params, 20);
69        ThreadSafeClientConnManager manager = new
    ThreadSafeClientConnManager(params,
70            schemeRegistry);
71        WebServiceUtil.httpClient = new DefaultHttpClient(manager,
    params);
72      }
73    }
74    return INSTANCE;
75  }
76
77  /**
78   * Make a post command to serviceURL with params and return the
79   * response String as a JSON array.
80   *
81   * @param serviceURL The URL of the server to post to.
82   * @param commandName The path to the command.
83   * @param params A List of NameValuePairs to send as parameters
84   * with the post.
85   * @param callback A callback function that accepts a JSON array
86   * on success.
87   */
88  public void postCommandReturningArray(String serviceURL, String
    commandName,
89      List<NameValuePair> params, final AsyncCallbackPair<JSONArray>
    callback) {
90    AsyncCallbackPair<String> thisCallback = new AsyncCallbackPair<
    String>() {
91      public void onSuccess(String httpResponseString) {
92        try {
93          callback.onSuccess(new JSONArray(httpResponseString));
```

```
94          } catch (JSONException e) {
95            callback.onFailure(e.getMessage());
96          }
97        }
98        public void onFailure(String failureMessage) {
99          callback.onFailure(failureMessage);
100       }
101     };
102     postCommand(serviceURL, commandName, params, thisCallback);
103   }
104
105   /**
106    * Make a post command to serviceURL with paramaterss and
107    * return the response String as a JSON object.
108    *
109    * @param serviceURL The URL of the server to post to.
110    * @param commandName The path to the command.
111    * @param params A List of NameValuePairs to send as parameters
112    * with the post.
113    * @param callback A callback function that accepts a JSON object
114    * on success.
115    */
116   public void postCommandReturningObject(final String serviceURL,final
        String commandName,
117       List<NameValuePair> params, final AsyncCallbackPair<JSONObject>
      callback) {
118     AsyncCallbackPair<String> thisCallback = new AsyncCallbackPair<
      String>() {
119     public void onSuccess(String httpResponseString) {
120         try {
121           callback.onSuccess(new JSONObject(httpResponseString));
122         } catch (JSONException e) {
123           callback.onFailure(e.getMessage());
124         }
125       }
126       public void onFailure(String failureMessage) {
127         callback.onFailure(failureMessage);
128       }
129     };
130     postCommand(serviceURL, commandName, params, thisCallback);
131   }
132
133   /**
134    * Make a post command to serviceURL with params and return the
135    * response String.
136    *
137    * @param serviceURL The URL of the server to post to.
138    * @param commandName The path to the command.
139    * @param params A List of NameValuePairs to send as parameters
140    * with the post.
141    * @param callback A callback function that accepts a String on
142    * success.
143    */
```

```
144   public void postCommand(final String serviceURL, final String
      commandName,
145       List<NameValuePair> params, AsyncCallbackPair<String> callback)
      {
146     Log.d(LOG_TAG, "Posting " + commandName + " to " + serviceURL + "
      with arguments " + params);
147
148     if (serviceURL == null || serviceURL.equals("")) {
149       callback.onFailure("No service url to post command to.");
150     }
151     final HttpPost httpPost = new HttpPost(serviceURL + "/" +
      commandName);
152
153     if (params == null) {
154       params = new ArrayList<NameValuePair>();
155     }
156     try {
157       String httpResponseString;
158       ResponseHandler<String> responseHandler = new
      BasicResponseHandler();
159       httpPost.setEntity(new UrlEncodedFormEntity(params, HTTP.UTF_8))
      ;
160       httpPost.setHeader("Accept", "application/json");
161       httpResponseString = httpClient.execute(httpPost,
      responseHandler);
162       callback.onSuccess(httpResponseString);
163     } catch (UnsupportedEncodingException e) {
164       Log.w(LOG_TAG, e);
165       callback.onFailure("Failed to encode params for web service call
      .");
166     } catch (ClientProtocolException e) {
167       Log.w(LOG_TAG, e);
168       callback.onFailure("Communication with the web service
      encountered a protocol exception.");
169     } catch (IOException e) {
170       Log.w(LOG_TAG, e);
171       callback.onFailure("Communication with the web service timed out
      .");
172     }
173   }
174 }
```

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