Scientific Community Game (SCG) Court

User Guide

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1. Introduction

For the objective of the CS 5500 / Managing Software Development course, we want to develop community support for running competitions of games that involve computational problems. In order to achieve this goal, a consistent interface must be developed so that playground designers may create unique games in an effective and efficient way. This guide describes the use of this system by specifying the procedures for defining playgrounds, preregistering and registering avatars capable of playing the games detailed within playground designs, running game tournaments amongst avatars, and analyzing the histories of previously completed tournaments.

2. Generic SCG Procedures

Regardless of how a playground is configured, the generic scientific community game procedures remain consistent. Specifically, the performance evaluations of competing avatars always result in a computation of updates to reputation. These performance evaluations take place after the completion of an opposition process (i.e., refutation, strengthening, or agreement). The following sections describe the different types of oppositions in detail and explain how reputation is handled at an abstract level.

2.1. Use of Reputation

When a tournament begins, the reputation for each of the avatars is equal. This initial reputation value can be configured by the playground designer using the configuration file constant.

During the duration of a tournament, a number of reputation updates will take place. In each update, reciprocal changes are made to the reputations of two avatars (i.e., a winner and a loser of a particular opposition). Therefore, reputation is zero-sum (as the winner gains the same amount that is deducted from the loser).

The following section describes the steps that lead to determining what reputation updates need to be made and which avatars those updates need to be applied to.

2.2. Opposition Process

During a tournament, avatars must both (A) propose new claims and (B) act on (i.e., oppose) the claims that have been proposed by other avatars. When an avatar opposes a claim, it must choose whether to [1] refute it, [2] strengthen it, or [3] agree with it. For each of these actions, there are a number of steps that must be carried out by the proposer (i.e., '*Alice*') and the opposer (i.e., '*Bob*'). These -steps vary based on the type of opposition and the protocol of the claim. The admin ensures that all the steps in the protocol is carried out and then the outcome of the protocol is determined based on the protocol predicate.

(NOTE: For the purposes of this documentation, always assume that '*Alice*' is the person making the claim and that '*Bob*' is the person acting on / opposing the claim.)

2.2.1. Refutation

Alice makes a claim C with protocol P and quality q^c and confidence cf. Bob refutes C.

The protocol P specifies the sequence of actions that are to be to be performed by Alice and Bob.

Depending on the protocol, either Alice or Bob (or both) will provide instance to be solved and solution for the given instances of claim C. The quality of the solution(s) and quality q^c will be used by the Protocol predicate - getResult(details of this is given in Section 4) to determine the outcome of the refutation. The result of this predicate is a value between 1 and -1. This result is used in computing the updates to the reputation of the 2 avatars.

If Bob successfully refutes the claim, Bob wins reputation and Alice loses reputation.
If Alice successfully defends her claim, Alice wins reputation and Bob loses reputation.

The reputation is updated as below:

Alice’s new reputation = Alice’s current reputation + (cf * result)

Bob’s new reputation = Bob’s current reputation - (cf * result)

Note:

result: Output of the Protocol predicate – getResult . This is a value between -1 and +1.

1 indicates refutation fails i.e. Alice wins.

-1 indicates refutation succeeds. Bob wins.

Any value between -1 and 1 indicates that the partial success of the refutation

2.2.2. Strengthening

Alice makes a claim C with protocol P and quality q and confidence cf.

Bob strengthens claim C with quality q1 and cf1 where cf1 >=cf. Alice refutes this strengthened claim.
The refutation follows the steps specified in the protocol P.

If Bob successfully defends his strengthened claim Bob wins. The reputation updates are as follows:

- Bob’s new reputation = Bob’s current reputation + (cf* absolute(q-q1))
- Alice’s new reputation = Alice’ current reputation - (cf * absolute(q-q1))

If Bob fails to defend his strengthened claim Alice wins. The reputation updates are as follows:

- Alice’s new reputation = Alice’s current reputation + cf1

- Bob’s new reputation = Bob’s current reputation – cf1

2.2.3. Agreement

Alice makes a claim C with quality q, confidence cf, and protocol P.

When Bob agrees on claim C with Alice, the following conditions should hold true.

- Bob must defend C against Alice.
- Bob must refute !C (negated claim of C - !C has the same InstanceSet, quality and confidence as C but has a protocol !P) with Alice as defender.

If Bob fails to satisfy any one of the above condition, then Bob loses.

Similarly Alice must satisfy the following conditions:

- Alice must defend C against Bob.
- Alice must refute !C with Bob as defender.

If Alice fails to satisfy any one of the above condition, then Alice loses.

If Bob loses,

- Reputation Update: Bob’s reputation = Bob’s reputation – cf
- Alice’s reputation = Alice’s reputation + cf

If Alice loses,

- Reputation Update: Alice’s reputation = Alice’s reputation – cf
- Bob’s reputation = Bob’s reputation + cf

If both Alice and Bob satisfy all their conditions then the reputations remain unaffected and the Claim goes into the social welfare set (Claim repository).

3. Domain Definitions

Designers that want to create games using computational problems can employ the scientific community game (i.e., "SCG") court system by authoring domain definitions. A domain definition consists of class definitions that represent how instances, claims, and solutions of a computational problem are constructed. Additionally, a domain definition includes the specification of rules for [1] deciding if a solution is valid for a particular instance, [2] calculating the quality of a valid solution, and [3] determining if a claim belongs to an instance. Finally, the designers must provide functionality that will serve as the foundation for creating basic avatars (i.e., "baby avatars") that are unsophisticated but capable of competing in tournaments without violating the game rules.

(NOTE: In the subsequent sections, it is suggested that calls to classes, functions, and file names starting with "DDS" are changed to start with a three letter representation of the domain that is being designed. While this suggestion is intended to simplify the process from converting the provided templates into a domain specific definition, it is not necessary to ensure functionality with the SCG court system.)

3.1. Domain Class Definitions

As mentioned, a particular domain design is comprised of class definitions that specify the necessary elements of a corresponding computational problem. These class definitions act as representations of the computational problem as a scientific community game in which [1] instances are proposed, [2] claims are made, and [3] solutions are provided, validated and computed. The following sections describe how to create domain class definitions by explaining the various required components and providing code samples (both at a generic and specific level).

3.1.1. Overview

When a designer wants to formalize a domain, they will need to define four **d**omain **d**esign **s**pecific (i.e., "`dds`") classes: [1] instance, [2] solution, [3] instance set, and [4] configuration:

- `ddsInstance`: Represents a single instance of a problem (i.e., a concrete question which can be solved by the game players).
- `ddsSolution`: Represents a solution corresponding to a given problem instance.
- `ddsInstanceSet`: Represents a set/collection of problem instances in our domain for which claims can be made (i.e., the abstract question to be solved).
- `ddsConfig`: Represents the customizable constraints for our domain.

These definitions are contained in a domain design specific class dictionary (i.e., "ddsDomain.cd").

3.1.2. Code Sample

The code sample below is a template class dictionary (i.e., "ddsDomain.cd") that domain designers can modify to specify their scientific community games. Within this code, comments (provided in green) explain the purpose of each line and/or what modifications are required when a domain designer is attempting to make changes. Additionally, it is interesting to note that this template, when coupled with the corresponding behavior file (.beh) template, will serve as a complete definition of the domain.

References to domain design specific data are denoted in orange (i.e., dds). During actual implementation, this text should be replaced with a three letter representation that distinguishes a particular domain. For example, an Instance in the Highest Safe Rung (i.e., hsr) domain would be called an hsrInstance. Therefore, a domain designer for the Highest Safe Rung problem would replace all dds text in the template below with hsr. Note that the class dictionary file name should also reflect this change. Therefore, the resulting file in this example would be named "hsrDomain.cd" if it were being created for the Highest Safe Rung problem.

Finally, definitions containing "[...]" should be replaced with unique and valid class definition components (see Section 3.1.3 for specific examples). For more details on class dictionary and behavior file see this DemeterF documentation.

```
/*
 * File: ddsDomain.cd
 * (replace all instances of dds, including the file name, with
 * a three letter representation of the domain name)
 */

/*
 * "scg.cd" includes the class definitions for SCG courts.
 *
 * Therefore, the SCG class dictionary has meta-level definitions
 * that specify how each domain level cd must be defined.
 */

nogen include "../scg/scg.cd";

/*
 * This domain definition will be created within the dds
 * package.
 */
```

```
package dds;

/*
 * Import the SCG level classes and interfaces.
 *
 * These are necessary to ensure that the domain level cd is
 * compatible with the SCG courts system.
 *
 * (After importing the SCG package, you should also import any
 * additional packages or classes that will be required for the
 * implementation of methods in your .beh file)
 */

import scg.*;
// Enter additional 'import' statements before this comment.

/*
 * NOTE: In the following definitions, you must replace "[...]"
 * with your unique & valid class definition components (see
 * Section 3.1.3 below for specific examples)
 */

/*
 * Define a domain design specific Instance.
 *
 * The ddsInstance definition must implement the InstanceI
 * interface. Therefore, InstanceI methods must be defined in
 * your corresponding behavior file (.beh) as part of the
 * ddsInstance class.
 */

ddsInstance = "[...]" implements InstanceI.

/*
 * Define a domain design specific Solution.
 *
 * The ddsSolution definition must implement the SolutionI
 * interface. Therefore, SolutionI methods must be defined in
 * your corresponding behavior file (.beh) as part of the
 * ddsSolution class.
 */

ddsSolution = "[...]" implements SolutionI.

/*
 * Define a domain design specific InstanceSet.
 *
```

```
         * The ddsInstanceSet definition must implement the InstanceSetI
         * interface. Therefore, InstanceSetI methods must be defined in
         * your corresponding behavior file (.beh) as part of the
         * ddsInstanceSet class.
         */

        ddsInstanceSet = "[...]" implements InstanceSetI.

        /*
         * Define a domain design specific Config.
         *
         * The ddsConfig definition must implement the DomainConfigI
         * interface. Default values for the config parameters defined
         * here is provided in your corresponding behavior file (.beh) as
         * part of the ddsConfig class /

        ddsConfig = "[...]" implements DomainConfigI.
```

3.1.3. Examples

The example provided below describes a domain design for the **c**onstraint **s**atisfaction **p**roblem (i.e., "CSP"). Therefore, these class definitions are included in a file named "cspDomain.cd". Comments (provided in green) explain the changes (provided in light blue). While these comments are unnecessary when actually creating a domain design, they are provided in this document to highlight what modifications were made from the original template (in Section 3.1.2).

```
        // File: cspDomain.cd

        // This line is the same in all domain designs:
        nogen include "../scg/scg.cd";

        // Changed package name from 'dds' to 'csp':
        package csp;

        // This line is the same in all domain designs:
        import scg.*;
        // Added import of the Iterator class for use in cspDomain.beh:
        import java.util.Iterator;

        /*
         * - Changed from 'ddsInstance' to 'cspInstance'
         * - Replaced "[...]" with CSP instance specific classes
         * - Maintained 'implements InstanceI' declaration
         */
```

```
cspInstance = <vars> List(Var) *s <clauses> Cons(Clause) implements
InstanceI.

Clause = "(" <relnum> int *s "{" <weight> int "}" *s <vars> List(Var)
")".

/*
 * - Changed from 'ddsSolution' to 'cspSolution'
 * - Replaced "[...]" with CSP solution specific classes
 * - Maintained 'implements SolutionI' declaration
 */
cspSolution = <assign> ListMap(Var,Boolean) implements SolutionI.

Var = <id> ident implements Comparable(Var).

/*
 * - Changed from 'ddsInstanceSet' to 'cspInstanceSet'
 * - Replaced "[...]" with CSP instance set specific classes
 * - Maintained 'implements InstanceSetI' declaration
 */
cspInstanceSet = "(" <type> ListSet(Integer) ")" implements
InstanceSetI.

/*
 * - Changed from 'ddsConfig' to 'cspConfig'
 * - Replaced "[...]" with CSP specific config parameters
 * - Maintained 'implements DomainConfigI' declaration
 */
cspConfig = "csp_config["
            //maximum value of relation number in Instance allowed
            *l*t "maxRelNum:" *s <maxRelNum> int
            //maximum no of variables allowed in Instance
            *l*t "maxVariables:" *s <maxVariables> int
             *l
      "]" implements DomainConfigI.            *l
```

3.2. Domain Behavior Definitions

For every domain design specific class dictionary, there must be equivalent domain design specific behavior definitions that specify the particular rules of the domain and how to compute solution qualities. This functionality is used by the admin to validate the legitimacy of game actions and determine the quality of the solution. Additionally, the domain behavior definitions illustrate how to decide whether or not an instance corresponds to a provided instance set. The following sections describe how to create domain behavior definitions by explaining the various required components and providing code samples (both at a generic and specific level).

3.2.1. Overview

When a designer wants to formalize a domain, they will need to define certain methods from SCG interfaces:

- `double` **`valid`**`(SolutionI solution)`: The "valid" method is used to check if the solution provided by the player is valid with respect to this Instance object. Defined in the "`ddsInstance`" class, it returns a double and is given a SolutionI. It returns 1 if the solution is valid or 0 if the solution is invalid.
- `double` **`quality`**`(SolutionI solution)`: The "quality" method is used to calculate the quality of the solution provided for this Instance object. Defined in the "`ddsInstance`" class, it returns a double and is given a SolutionI. It returns the quality as double between 0 to 1 (with 0 being the least quality and 1 being the max quality).
- `Option<String>` **`belongsTo`**`(InstanceI instance)`: The "belongsTo" method checks if the instance provided by the player corresponds to this InstanceSet. Defined in the "`ddsInstanceSet`" class, it returns an Option<String> with an error string if the instance does not belong to this InstanceSet or a None<String> if there is no error.

These definitions are contained in a domain design specific domain behavior file (i.e., "`ddsDomain.beh`").

3.2.2. Code Sample

The code sample below is a template behavior definition (i.e., "`ddsDomain.beh`") that domain designers can modify to specify functions for their scientific community games. Within this code, comments (provided in green) explain the purpose of each line and/or what modifications are required when a domain designer is attempting to make changes.

References to domain design specific data are denoted in orange (i.e., `dds`). During actual implementation, this text should be replaced with a three letter representation that distinguishes a particular domain. For example, the Instance class in the Highest Safe Rung (i.e., `hsr`) domain would be the `hsrInstance` class. Therefore, a domain designer for the Highest Safe Rung domain would replace all `dds` text in the template below with `hsr`. Note that the behavior file name should also reflect this change. Therefore, the resulting file in this example would be named "`hsrDomain.beh`" if it were being created for the Highest Safe Rung problem.

Finally, any cases of `return null;` should be replaced with unique and valid Java code (see Section 3.2.3 for specific examples).

```
/*
 * File: ddsDomain.beh
 * (replace all instances of dds, including the file name, with
 * a three letter representation of the domain name)
 */

/*
 * Methods for the ddsInstance class.
 *
 * The ddsInstance class must implement the InstanceI interface.
 * Therefore, the 'valid' and 'quality' methods must be
 * implemented.
 */
ddsInstance {{
// Checks if a solution is valid with respect to this ddsInstance
public double valid(SolutionI solution)
{
      // Replace with domain specific logic:
      return null; // Must return a 'double' object
}

/*
 * Calculate the quality of a solution with respect to this
 * ddsInstance
 */
public double quality(SolutionI solution)
{
      // Replace with domain specific logic:
      return null; // Must return a 'double' object
}

/*
 * Include helper methods for the 'valid' and/or 'quality'
 * methods here (i.e., before the double curly brackets)
 */

}}

/*
 * Methods for the ddsInstanceSet class.
 *
 * The ddsInstanceSet class must implement the InstanceSetI
 * interface. Therefore, the ‘belongsTo’ method must be
 * implemented.
 */
ddsInstanceSet {{
// Check if an instance belongs to this ddsInstanceSet
public Option<String> belongsTo(InstanceI instance)
{
      // Replace with domain specific logic:
      return null; // Must return an ‘Option<String>’ object
}


/*
 * Include helper methods for the ‘belongsTo’ method here
 * (i.e., before the double curly brackets)
 */

}}

/*
 * Customisable Config parameters for dds Domain.
 * The ddsConfig must have DEFAULT_dds_CONFIG,
 * which have default config values for the config
 * parameters defined in ddsDomain.cd
 * It should also have implementation for
 * getDefaultDomainConfig() and getDefaultConfig(),
 * which return DEFAULT_dds_CONFIG and Config respectively. */
ddsConfig {{

private static ddsConfig DEFAULT_dds_CONFIG;
static{
      try{
            DEFAULT_dds_CONFIG = ddsConfig.parse(

                  "dds_config[\n" +
                  "dds_config1: [default value]\n" +
                  "dds_config2: [default value]\n" +
                  "]"
            );
      }catch(Exception ex){
            ex.printStackTrace();
      }
}

public static ddsConfig getDefaultDomainConfig(){
      return ddsConfig.DEFAULT_dds_CONFIG;
}

public static Config getDefaultConfig(){
      return new Config(SCGConfig.getDefaultSCGConfig(),
      getDefaultDomainConfig());
}

}}
```

3.2.3. Examples

The example provided below describes the rules and regulations for the **c**onstraint **s**atisfaction **p**roblem (i.e., "CSP"). Therefore, these behavior definitions are included in a file named "cspDomain.beh". Comments (provided in green) explain the changes (provided in light blue). While these comments are unnecessary when actually creating a behavior file, they are provided in this document to highlight what modifications were made from the original template (in Section 3.2.2). Additional comments (in black) explain the implemented code functionality.

```
      // File: cspDomain.beh

      /*
       * Methods for the cspInstance class.
       *
       * The cspInstance class must implement the InstanceI interface.
       * Therefore, the 'valid' and 'quality' methods must be
       * implemented.
       */
      cspInstance {{
      // Checks if a solution is valid with respect to this cspInstance
      public double valid(SolutionI solution)
      {
            // Cast the SolutionI object to a CSPSolution object
            CSPSolution cspSolution = (CSPSolution) solution;

            // If the number of assignments does not equal the number of
```

```
variables...
      if ( cspSolution.getAssign().size() != getVars.length() )
            return 0; // ...return 0 (i.e., not valid)

      // Validation variable
      boolean isValid = true;
      // Iterator (to check if each var instance is contained in the
assignment)
      Iterator<Var> vars = getVars().iterator();

      // For each var in the Iterator...
      for(vars; vars.hasNext();)
      {
       /*
        * check if the current var is accounted for in the assignment
        * and store the result of this check (and similar subsequent
        * checks) in the validation variable
        */
            isValid &=
cspSolution.getAssign().containsKey(vars.next());
      }

      // Return the result of the findings
      if (isValid) return 1;
      else return 0;
}

/*
 * Calculate the quality of a solution with respect to this
 * cspInstance
 */
public double quality(SolutionI solution)
{
      // Cast the SolutionI object to a CSPSolution object
      CSPSolution cspSolution = (CSPSolution) solution;

      // Store the List of Var/Boolean pairs
      List<Entry<Var, Boolean>> s = cspSolution.getAssign().toList();
      // Store the List of Clauses from this CSPInstance
      List<Clause> list = getClauses();
      //Quality is calculated as number of clauses in the list that the
cspSolution satisfies. This quality is always between 0 and 1. 0
indicating that cspSolution satisfies none of the clauses in list and 1
indicates that cspSolution satisfies all the clauses in list.
```

```
}

/* Any additional helper methods required to compute quality or valid
goes here*/

}}

/*
 * Methods for the cspInstanceSet class.
 *
 * The cspInstanceSet class must implement the InstanceSetI
 * interface. Therefore, the 'belongsTo' method must be
 * implemented.
 */
cspInstance {{
// Check if an instance belongs to this cspInstanceSet
public Option<String> belongsTo(InstanceI instance)
{
      // Cast the InstanceI object to a CSPInstance object
      CSPInstance i = (CSPInstance) solution;
      // Verification variable
      boolean valid = true;
      // Iterator
      Iterator<Clause> clauses = i.getClauses().iterator();

      // For each clause in the Iterator...
      for(clauses; clauses.hasNext();)
      {
            // ...store the clause in a variable...
            Clause clause = clauses.next();
            /*
             * see if this relation number in the clause
             * is present in the CSPInstanceSet then valid else invalid
             */
            valid &= getType().contains(clause.getRelnum());
      }

      // Return the result of the findings
      if(!valid)
      {
            return new Some<String>("The instance " + i.print() +
            " is different from " + this.print() + ".");
      }
      return new None<String>();
```

```
       }

       }}


    cspConfig {{
            private static cspConfig DEFAULT_csp_CONFIG;
            static{
                  try{
                         DEFAULT_csp_CONFIG = cspConfig.parse(

                         "csp_config[\n" +
                         "maxRelNum: 255\n" +
                         "maxVariables: 10\n" +
                         "]"
                         );
                  }catch(Exception ex){
                         ex.printStackTrace();
                  }
            }

            public static cspConfig getDefaultDomainConfig(){
                  return cspConfig.DEFAULT_csp_CONFIG;
            }

            public static Config getDefaultConfig(){
                  return new Config(SCGConfig.getDefaultSCGConfig(),
getDefaultDomainConfig());
            }
        }}
```

3.3. Avatar Definition

In addition to the domain specific class definitions and the domain behavior definitions, designers must provide an avatar definition that is specific to their domain. As previously mentioned, this avatar definition is used in the creation of a baseline avatar that is capable of playing the game without violating the rules. However, this avatar lacks any kind of sophisticated logic. Therefore, its functionality is mostly only useful for providing scholars with a solid framework from which they can implement better algorithmic strategies for competing in tournaments.

3.3.1. Overview

When a designer wants to create an avatar definition for their domain, they will need to define certain methods from the AvatarI interface (at the SCG level):

- `List<Claim>` **`propose`**`(List<Claim> forbiddenClaims)`: The "propose" method is used to make new claims during competitions.
- `List<OpposeAction>` **`oppose`**`(List<Claim> claimsToBeOpposed)`: The "oppose" method is used to respond to the claims of the proposer given in the input parameter `claimsToBeOpposed`.
- `InstanceI` **`provide`**`(Claim claimToBeProvided)`: the "provide" method is used to provide an instance of the instanceSet for the given claim.
- `SolutionI` **`solve`**`(SolveRequest solveRequest)`: the "solve" method is used to provide solution for the instance provided. This solution will be used to determine the outcome of the opposing action.

These definitions are contained in a domain design specific avatar behavior file (i.e., "`ddsAvatar.beh`"). Additionally, a domain design specific avatar class dictionary (i.e., "`ddsAvatar.cd`") must be created so that the function definitions from the avatar behavior file can be automatically generated using DemeterF.

3.3.2. Code Samples

The code samples below represent a template class dictionary (i.e., "`ddsAvatar.cd`") and a template behavior definition (i.e., "`ddsAvatar.beh`") needed for a complete avatar definition. Within this code, comments (provided in green) explain the purpose of each line and/or what modifications are required when a domain designer is attempting to make changes.

References to domain design specific data are denoted in orange (i.e., `dds`). During actual implementation, this text should be replaced with a three letter representation that distinguishes a particular domain. For example, the Avatar class in the Highest Safe Rung (i.e., `hsr`) domain would be denoted by the "`hsrAvatar`" class. Therefore, a domain designer for the Highest Safe Rung problem would replace all "`dds`" text in the template below with "`hsr`". Note that file names should also reflect this change. Therefore, the resulting files in this example would be named "`hsrAvatar.cd`" (for the class dictionary) and "`hsrAvatar.beh`" (for the behavior file) if they were being created for the Highest Safe Rung problem.

```
/*
 * File: ddsAvatar.cd
 * (replace all instances of dds, including the file name, with
 * a three letter representation of the domain name)
 */

/*
 * “scg.cd” includes the class definitions for SCG courts.
 *
 * Therefore, the SCG class dictionary has meta-level definitions
 * that specify how each avatar definition cd must be defined.
 */

nogen include "../scg/scg.cd";

/*
 * This avatar definition will be created within the
 * dds.Avatar package.
 */

package dds.Avatar;

/*
 * - Import the SCG package.
 * (necessary to ensure that this avatar is compatible with the
 * SCG courts system)
 * - Import the DDS package.
 * (necessary to ensure that this avatar can interact with
 * dds specific objects)
 *
 * After importing the SCG and DDS packages, you should also
 * import any additional packages or classes that will be
 * required for the implementation of methods in your .beh file
 */

import scg.*;
import dds.*;

// Enter additional ‘import’ statements before this comment.

/*
 * Define a domain design specific Avatar (i.e., ddsAvatar).
 *
 * The ddsAvatar definition must extend the abstract AvatarI
 * class. Therefore, relevant AvatarI methods must be defined in
 * your corresponding behavior file (.beh) as part of the
```

```
         * ddsAvatar class (see the template avatar behavior definition
         * template for more details).
         */

        ddsAvatar = implements AvatarI.
```

```
        /*
         * File: ddsAvatar.beh
         * (replace all instances of dds, including the file name, with
         * a three letter representation of the domain name)
         */

        /*
         * Methods for the ddsAvatar class.
         *
         * The ddsAvatar class must extend the abstract AvatarI class.
         * Therefore, the 'propose', 'oppose', 'provide', and 'solve'
         * methods must be implemented.
         */
        ddsAvatar {{

        /*
         * The constructor for the ddsAvatar class contains a Config
         * object.
         */
        private Config config;

        /*
         * The constructor to be called during registration (where you
         * supply a Config)
         */
        public ddsAvatar(Config cfg)
        { config = cfg; }

        /*
         * Proposes a List<Claim> that does not include any claims
         * from the given List<Claim> (i.e., forbidden claims)
         */
        public List<Claim> propose(List<Claim> forbiddenClaims)
        {
              // Replace with domain specific logic:
              return null; // Must return a 'List<Claim>' object
        }
```

```
      // Decides what opposition action to take for each claim in the given
      List<Claim>.
      public List<OpposeAction> oppose(List<Claim> claimsToBeOpposed)
      {
            // Replace with domain specific logic:
            return null; // Must return a 'List<OpposeAction>' object
      }

      // Provides a ddsInstance for the given Claim
      public InstanceI provide(Claim claimToBeProvided)
      {
            // Replace with domain specific logic:
            return null; // Must return a 'ddsInstance' object
      }

      // Solves (i.e., gives a ddsSolution) for the instance in the given
      SolveRequest
      public SolutionI solve(SolveRequest solveRequest)
      {

             ddsInstance i = (ddsInstance)solveRequest.getInstance();
            // Replace with domain specific logic:
            return null; // Must return a 'ddsSolution' object
      }

      /*
       * Include helper methods for the 'propose', 'oppose', 'provide',
       * and/or 'solve' methods here (i.e., before the double curly
       * brackets)
       */

      }}
```

3.3.3. Examples

The example provided below describes an avatar definition for the **c**onstraint **s**atisfaction **p**roblem (i.e., "CSP"). Therefore, this avatar definition consists of two files - a class dictionary file named "cspAvatar.cd" and a behavior definition file named "cspAvatar.beh". Comments (provided in green) explain the changes (provided in light blue). While these comments are unnecessary when actually creating an avatar definition, they are provided in this document to highlight what modifications were made from the original template (in Section 3.3.2). Additional comments (in black within the behavior definition) explain the implemented code functionality.

```
// File: cspAvatar.cd

// This line is the same in all avatar definitions:
nogen include "../scg/scg.cd";

// Changed package name from 'dds.Avatar' to . csp.Avatar'
package csp.Avatar;

// This line is the same in all avatar definitions:
import scg.*;
// Changed package name from 'dds.*' to 'csp.*'
import csp.*;
// Added import of the Random class (for use in cspAvatar.beh):
import java.util.Random;

// Changed from 'ddsAvatar' to 'cspAvatar'
cspAvatar = extends AvatarI.
```

```
// File: cspAvatar.beh

/*
 * Methods for the cspAvatar class.
 *
 * The cspAvatar class must extend the abstract AvatarI class.
 * Therefore, the 'propose', 'oppose', 'provide', and 'solve'
 * methods must be implemented.
 */
cspAvatar {{

/*
 * The constructor for the cspAvatar class contains a Config
 * object.
 */
private Config config;


/*
 * The constructor to be called during registration (where you
 * supply a Config)
 */
public cspAvatar(Config cfg)
{ config = cfg; }

/*
```

```
         * Proposing random claims which are not in the given List<Claim>
         * (i.e., forbidden claims)
         *
         * These random claims are added to a List<Claim>, which is
         * eventually the object that is returned.
         */
        public List<Claim> propose(List<Claim> forbiddenClaims)
        {
                // Start with an empty List<Claim> object
                List<Claim> claims = List.create();

                // Do the following x number of times (0 < x < max number of
        proposals)...
                for(int i=0; i < config.getScgCfg().getMaxProposals(); i++)
                {
                        // ...get a random claim (from the 'generateRandomClaim'
        method)...
                        Claim claim = generateRandomClaim();

                        /*
                         * ...make sure it is unique (i.e., not in the
                         * forbidden list or in our list already)...
                        while(forbiddenClaims.contains(claim) &&
                                claims.contains(claim) )
                        { claim = generateRandomClaim(); }

                        // ...and add it to the list to eventually be proposed
                        claim = claims.append(claim);
                }

                // Return the resulting List<Claim>
                return claims;
        }

        // Decides which claims from the given List<Claim> to oppose
        public List<OpposeAction> oppose(List<Claim> claimsToBeOpposed)
        {

            return claimsToBeOpposed.map(new List.Map<Claim, OpposeAction>() {
                        public OpposeAction map(Claim claim){
                            /* for each claim decide which of the 3 options
                             * Refuting
                             * Strengthening
                             * Agreement
                             * needs to be taken.
                             * Solve method can help assist in choosing the action
                             */
```

```
                    return null; //Must return a OpposeAction object

                  });
       }

       // Provides a cspInstance for the given Claim
       public InstanceI provide(Claim claimToBeProvided)
       {
           cspInstanceSet cspInstanceSet = (cspInstanceSet)
                claimToBeProvided.getInstanceSet();
          // create one instance from this instanceSet cspInstanceSet
             return null; // Must return a 'cspInstance' object
       }

       // Solves (i.e., gives a cspSolution) for the given instance in
       SolveRequest
       public SolutionI solve(SolveRequest solveRequest)
       {

             cspInstance i = (cspInstance)solveRequest.getInstance();
             /* write logic to solve this instance i and provide its solution
              * solution is a cspSolution object
              */
             return null; // Must return a 'cspSolution' object
       }

       }}
```

4. Protocol Definitions

A protocol includes a sequence of steps involved in refuting a claim and a predicate that determines the outcome of the refutation. For the purposes of this documentation, always assume that ‘Alice’ is the person making the claim and that ‘Bob’ is the person refuting the claim. Strengthening and Agreement of a claim use the defined steps in refutation protocol.

Each step in the protocol involves Alice or Bob providing data. Data includes instances and solutions. Once all the steps are completed, then the predicate evaluates the outcome of the refutation using these instances and solutions.

When designers are defining new domains, they can use the protocols that already exist in the SCG. But if the domain demands sequence of steps and the evaluation predicate which cannot be satisfied by the existing protocols, then the Designers have to define a new protocol.

Rule:
When the protocol designer defines a new Protocol, then it is mandatory that he defines a Protocol for positive claim and a negative claim. This is mandatory condition imposed by SCG as the protocol for negated claim is useful in agreement of a claim (as shown in Reputation Rules section).

A protocol is a java class which implements ProtocolI interface. This interface mandates that the new protocol class defines 2 methods:

- A predicate that determines the outcome of the refutation.

Method Signature:

```
double getResult(Claim claim, SolutionI[] solutions, InstanceI[] instances);
```

- A method to fetch the sequence of steps specified in the protocol.

Method signature:

```
ProtocolSpec getProtocolSpec();
```

The following sections [1] illustrate a part of SCG class dictionary which indicates how to specify the protocol steps, [2] illustrate a template java class to help the protocol designers with designing new Protocols, and [3] provide an example of a protocol called NegativeSecret.

4.1. Protocol Steps

```
        ProtocolSpec = <steps> List(Step).

        Step = <action> Action "from" <role> Role .

        interface Role = Alice | Bob.

        Alice = "Alice".

        Bob = "Bob".

        interface Action = ProvideAction | SolveAction.

        //can only provide for the claim

        ProvideAction = "instance".

        //solve the instance provided in step # stepNo

        //step # -1 for the singleton instance in claim

        // stepNo is 0-based

        SolveAction = "solution" "of" *s <stepNo> int.
```

An example of the protocol steps, which confers to the above class dictionary, is given below.

```
         instance from Alice

         solution of 0 from Alice

         solution of 0 from Bob
```

This protocol has following steps:

- The player playing the role of Alice has to provide an instance as first step.
- The player playing the role of Alice has to provide a solution for instance in first step.
- The player playing the role of Bob has to provide a solution for instance in first step.

4.2. Code Sample

The code sample below is a template class (i.e., “Protocol.java”) that protocol designers can modify to specify their new protocol.

Within this code, comments (provided in green) explain the purpose of each line and/or what modifications are required when a protocol designer is attempting to make changes. References to the new protocol are denoted in orange (i.e., protocol). During actual implementation, this text should be replaced with the actual name that distinguishes a particular protocol. The text in blue is to be replaced with protocol specific text.

```
package scg.protocol;

import scg.*;

public class protocol implements ProtocolI{

      private static ProtocolSpec PROTOCOL_SPEC;
      static{
            try{
                  PROTOCOL_SPEC = ProtocolSpec.parse(
                      /* sequence of steps involving Alice/Bob providing
                       * Instance/solution.
                       * See  section 4.1 to define this
                       */
                      […]
                  );
            }catch(Exception ex){
                  ex.printStackTrace();
            }
      }

      /* This method always returns a real number between -1 and 1.
       * If number is negative then it indicates that refutation is
       * successful and Bob wins.
       * If number is positive then it indicates that refutation fails and
       * Alice successfully defends
       */
      public double getResult(Claim claim, SolutionI[] solutions,
                  InstanceI[] instances) {
             /* code which evaluates the quality of solutions for
              * the instances.
              * The quality of the claim can also be considered
              * for this evaluation.
              */
            [….]
      }

      public ProtocolSpec getProtocolSpec(){
            return protocol.PROTOCOL_SPEC;
      }

      private static protocol instance = new protocol();

      public static protocol getInstance() {
            return instance;
      }

}
```

4.3. Example

The example provided below describes the NegativeSecret protocol. Comments (provided in green) explain the changes (provided in light blue). These comments have to be removed from the file when actually creating the protocol class. They are provided in this document to highlight what modifications were made from the original template (in Section 4.2).

```
// File: protocol.java

package scg.protocol;
import scg.*;

/* Replaced protocol with NegativeSecret */
public class NegativeSecret implements ProtocolI{

      private static ProtocolSpec PROTOCOL_SPEC;
      static{
            try{
                  /* Replace […] with protocol specific steps */
                  PROTOCOL_SPEC = ProtocolSpec.parse(
                  "instance from Alice " +
                  "solution of 0 from Alice " +
                  "solution of 0 from Bob "
                  );
            }catch(Exception ex){
                  ex.printStackTrace();
            }
      }

      /*
      * Replaced […] with the code which determines the result using
      * the instances and solution specifies in the protocol steps.
      * The code in blue evaluates the solution given by Alice and
      * Bob for the instance provided by Alice.
      * It compares the quality of the 2 solutions and
      * also uses claim quality in the comparison to evaluate the
      * outcome of the refutation.
      */
      public double getResult(Claim claim, SolutionI[] solutions,
                  InstanceI[] instances) {
            if(solutions.length == 2 && instances.length == 1){
                  InstanceI i = instances[0];
                  SolutionI aliceSolution = solutions[0];
                  SolutionI bobSolution = solutions[1];
                  if(i.quality(bobSolution) >= (i.quality(aliceSolution) *
claim.getQuality()))
                        return -1; //Bob win
                  else
                        return 1; //Alice win
            }
            return 0; // Draw
      }

      public ProtocolSpec getProtocolSpec(){
            return NegativeSecret.PROTOCOL_SPEC;
      }

      private static NegativeSecret instance = new NegativeSecret();

              public static NegativeSecret getInstance() {
            return instance;
               }

}
```

5. Playground Configuration

After a domain has been fully defined and a protocol has been selected, they can be used as part of a playground configuration. A playground configuration defines the constraints for a particular tournament.

The playground configuration consists of 2 parts:

- SCGConfig – configurations enforced by the SCG courts. While this obviously includes the specification of which domain and protocol(s) to use, it also includes setting generic parameters that apply to any scientific community game.
- Domain Config – configurations specific to a domain. These are constraints which the domain designers want to define for instances, solutions and instanceset of their domain.

(NOTE: In the current implementation, playground configurations are restricted to utilizing only domains and protocols that are natively included as part of the SCG court system. Therefore, it is not possible to use newly created domains and protocol when creating a tournament. In future implementations, it should be possible to submit non-native domains and protocols simultaneously with a playground configuration or update the SCG court system with new domains and protocols beforehand via an external interface).

5.1 SCG Configuration

The SCG configuration class (i.e., `SCGConfig`) is defined within the SCG level class dictionary(scg.cd). The following sections [1] describe why each parameter within a SCG configuration is important.

The parameters in SCG configuration are:

- domain: fully qualified class name of Domain used. This indicates the Domain used for the game.
- protocols: fully qualified class names of protocols used. This indicates the protocols that can be used in the game.
- tournamentStyle: any one of 'full round-robin' or 'knockout' or 'swiss'
- turnDuration: an integer indicating number of seconds alloted for each avatar turn
- maxNumAvatars: an integer indicating maximum number of avatar allowed
- minStrengthening: a double indicating minimum value by which a claim should be strengthened
- initialReputation: an integer indicating initial reputation of the avatars

- maxReputation: a double indicating maximum reputation of the avatars
- reputationFactor: a double in [0,1] used to determine reputation gain upon successful defense of own claim or upon successful refutation of claim of another scholar.
- minProposals: an integer inidicating minimum number of proposals which has to be in a response from avatar
- maxProposals: an integer inidicating minimum number of proposals which has to be in a response from avatar
- numRounds: an integer inidicating number of rounds to be played in the game
- proposedClaimMustBeNew: a boolean indicating whether proposed claims must be different from previously proposed claims

5.2 Domain Configuration

The Domain level config specifies the configurations/constraints for a given domain. The Domain Configuration Class(ddsConfig) is defined in domain class dictionary and it which implements DomainConfigI interface. The Example in Section 5.4 shows how domain level constraints are specified for CSP game.

5.3 Code Sample

The code sample below is a template config definition (i.e., “ddsConfig.txt”) that playground designers can specify to customize the existing game domains in SCG to satisfy their needs.

References to domain design specific data are denoted in orange (i.e., dds). During actual implementation, this text should be replaced with a three (or more) letter representation that distinguishes a particular domain.

All parameters within scg_config[….] are SCG configurations. All parameters within dds_config[….] are domain configurations.

All […] in the scg_config should be replaced by suitable value as defined in the SCG config section. All … in dds_config should be replaced by suitable parameter values which are specified in ddsConfig in domain class dictionary (defined in Section 3.1.3).

```
scg_config[
domain:[...]
protocols: [...]
tournamentStyle: [...]
turnDuration: [...]
maxNumAvatars: [...]
minStrengthening: [...]
initialReputation: [...]
maxReputation: [...]
reputationFactor: [...]
minProposals: [...]
maxProposals: [...]
numRounds: [...]
proposedClaimMustBeNew: [...]
]
/* replace the fully qualified class name of Domain Config with fully
 * qualified name of the ddsConfig class defined in ddsDomain.cd
 */
[fully qualified class name of Domain Config] {{ dds_config[
...
]
}}
```

5.4 Example

The example provided below describes one possible configuration for the constraint satisfaction problem (i.e., "CSP"). Comments (provided in green) explain the changes (provided in light blue). These comments have to be removed from the file when actually creating the domain config file. They are provided in this document to highlight what modifications were made from the original template (in Section 5.3).

```
scg_config[
domain:csp.CSPDomain
protocols: scg.protocol.NegativeSecret scg.protocol.PositiveSecret
tournamentStyle: full round-robin
turnDuration: 60
maxNumAvatars: 20
minStrengthening: 0.01
initialReputation: 100.0
maxReputation: 1000.0
reputationFactor: 0.4
minProposals: 2
maxProposals: 5
numRounds: 9
proposedClaimMustBeNew: true
]

/* the definition of parameters in CSPConfig is in section 3.1.3 */
csp.CSPConfig {{ csp_config[
maxRelNum: 255
maxVariables: 10
]
}}
```

6. Managing Tournaments & Users

The SCG court system manages tournament initialization and provides relevant data via a simple web interface. Through this, administrators can create new tournaments that approved users can enroll in and eventually register for. If a user is not yet approved, they can also sign up for an account and request access, which is controlled by the administrator. The following sections detail the various levels of functionality contained in the aforementioned interface and outline the standard chronological procedure for operating a successful tournament.

(NOTE: Images shown in the subsequent sections have been slightly aesthetically modified for document integration. Furthermore, the address in the images points to *localhost*. Consult your system administrator for the address of your specific SCG court system.)

6.1. Sign In

The sign in page is the primary entry point to the web interface. From here, administrators can log in and access the admin control panel (see Section 6.2). Similarly, regular users can also log in and access any tournaments in the system using this page. If you don't have an account, you can sign up for one via the "Sign Up" link at the bottom. However, signing in with that account will be prohibited until the administrator approves it.

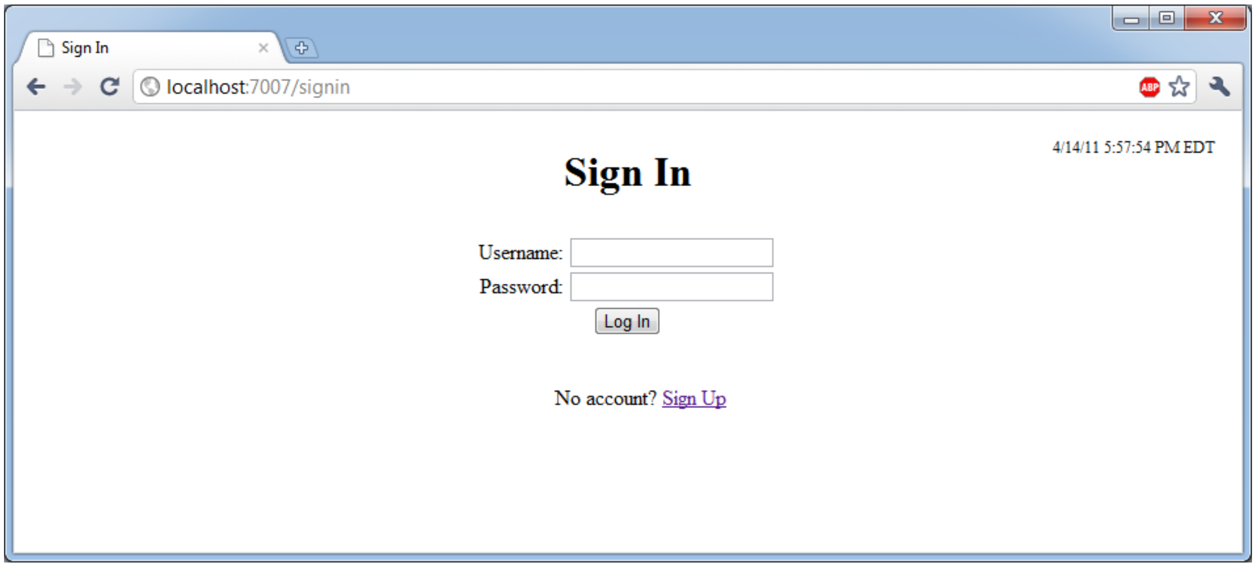
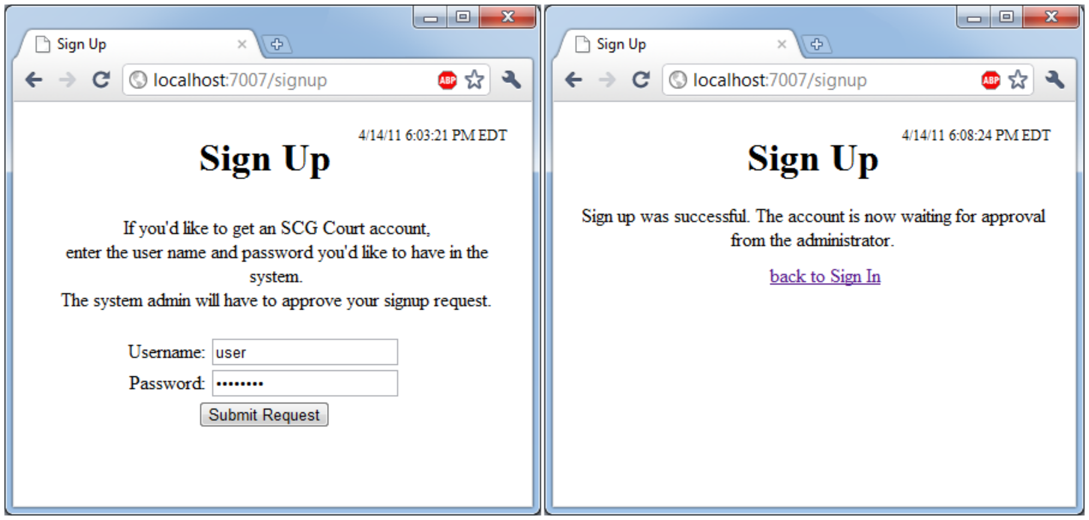


Figure A : The Sign In Page

6.1.1. Sign Up

As mentioned, potential users can sign up for an account by clicking the appropriate link from the sign in page. Once they have submitted their request, they will be notified that the process was successful and that the account is awaiting approval. The user will be able to sign in after the administrator approves the account with the credentials that were used in during the sign up process.



Sign Up

localhost:7007/signup

4/14/11 6:03:21 PM EDT

Sign Up

If you'd like to get an SCG Court account,
enter the user name and password you'd like to have in the system.
The system admin will have to approve your signup request.

Username: user
Password: ••••••••

Sign Up

localhost:7007/signup

4/14/11 6:08:24 PM EDT

Sign Up

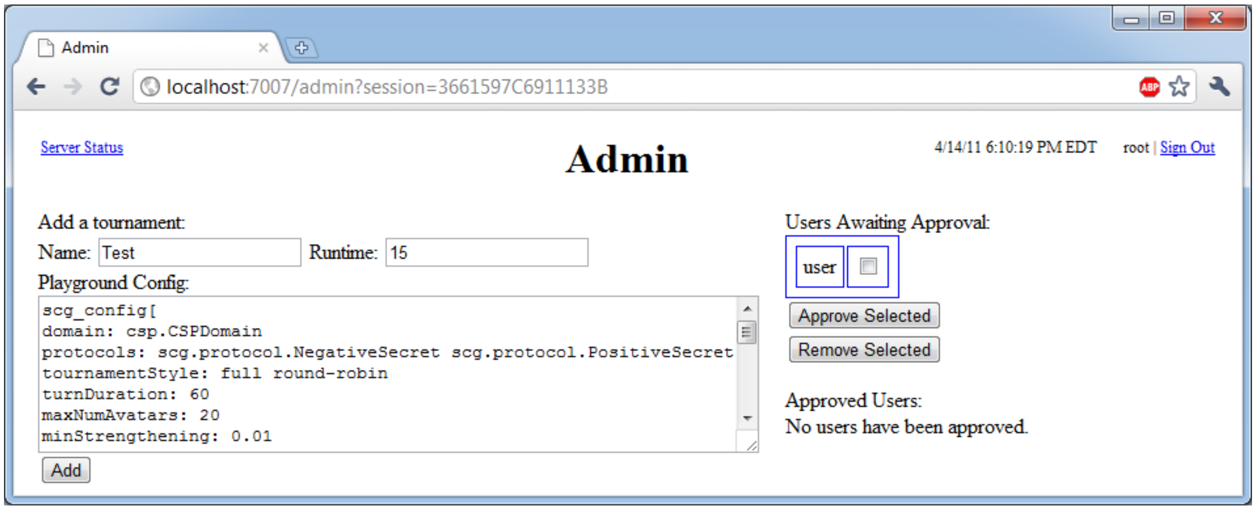
Sign up was successful. The account is now waiting for approval from the administrator.

back to Sign In

Figure B: Signing Up

6.2. Admin Control Panel

The Admin Control Panel enables the admin to control and maintain the tournaments, users of SCG court. Access to the admin control panel can be obtained by entering the proper credentials at the sign in page. Once the username and password is validated, a page will appear with options to [1] add a tournament, [2] approve or remove users, and [3] view the server status (i.e., manage existing tournaments). Adding a tournament and approving/removing users are both relatively simple processes whereas viewing the server status yields more complex functionality.



```
scg_config[
domain: csp.CSPDomain
protocols: scg.protocol.NegativeSecret scg.protocol.PositiveSecret
tournamentStyle: full round-robin
turnDuration: 60
maxNumAvatars: 20
minStrengthening: 0.01
```

Figure C: The Admin Control Panel

6.2.1. Adding Tournaments

To add a tournament, the administrator must provide 3 pieces of data:

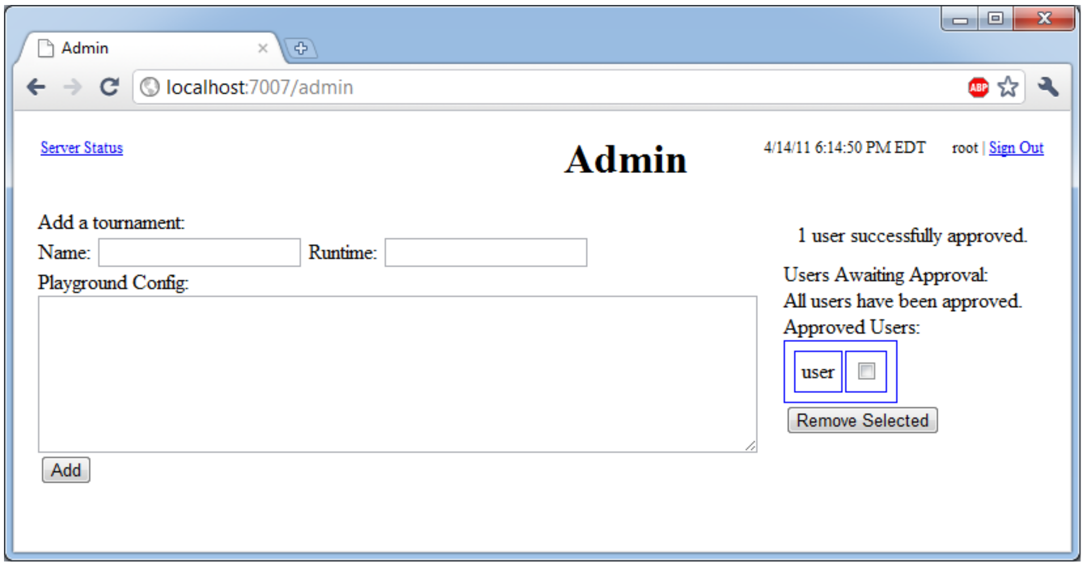
- `Name`: An arbitrary title used to identify the tournament on the server.
- `Runtime`: The number of minutes before the tournament will start.
- `Playground Config`: A valid playground configuration object (as described in section 5).

After providing this information and clicking the 'Add' button, the web interface will notify the administrator if there were errors in creating the tournament or if it has been scheduled successfully.

The example shown in the images creates a tournament named "Test" that starts in 15 minutes using the playground configuration from section 5.4.

6.2.2. Approving/Removing Users

Besides adding tournaments, the administrator can approve or remove users directly from the admin control panel. After logging in, pending users (i.e., “users awaiting approval”) will be shown on the right (see *Figure C*). Additionally, the administrator can elect to remove users that had previously been approved (see *Figure D*).



1 user successfully approved.

Users Awaiting Approval:
All users have been approved.
Approved Users:

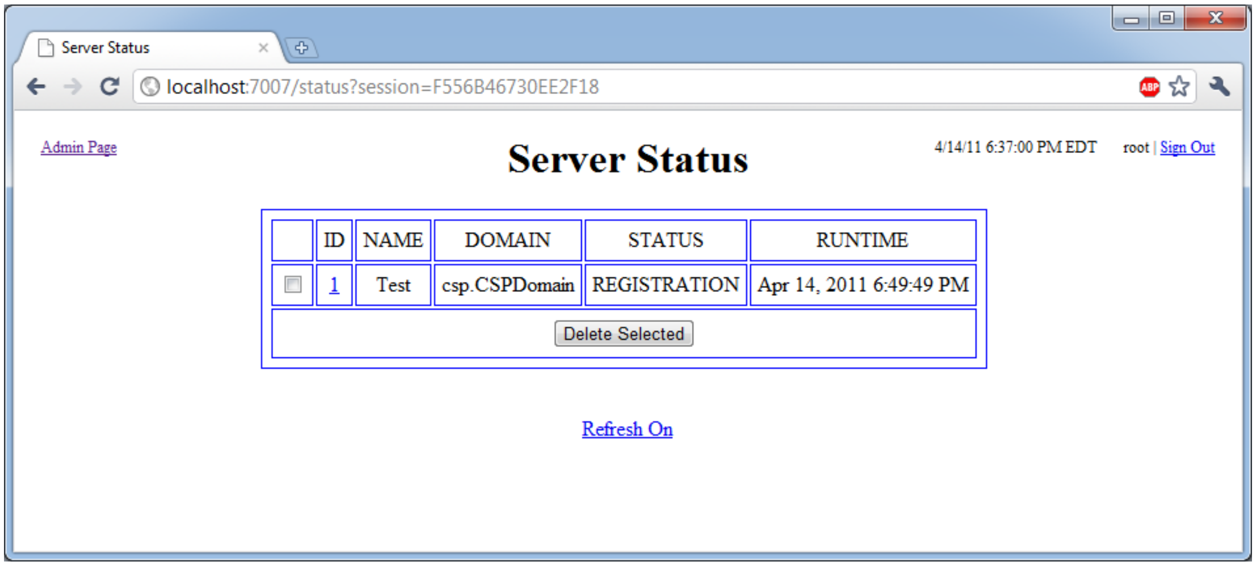
user	☐

Figure D: The Admin Control Panel (after approving a user)

6.3. Server Status Page

Once there is a sufficiently large group of approved users and at least one tournament has been created, it will be useful for the administrator to access the server status page to monitor any existing tournaments. By clicking the "Server Status" link at the top left of the admin control panel, the administrator will be brought to a page with a list of existing tournaments, which includes relevant information such as tournament ID number, tournament name, and tournament status. Additionally, tournaments that are no longer needed can be deleted from this page by clicking the checkbox in the corresponding row and selecting the 'Deleted Selected' button.

As a regular user, the server status page is the first accessible page after logging in. These users will also be able to view all the necessary details pertaining to existing tournaments. However, they will obviously be unable to navigate to the admin control panel or delete tournaments from this page.



Server Status

	ID	NAME	DOMAIN	STATUS	RUNTIME
☐	1	Test	csp.CSPDomain	REGISTRATION	Apr 14, 2011 6:49:49 PM

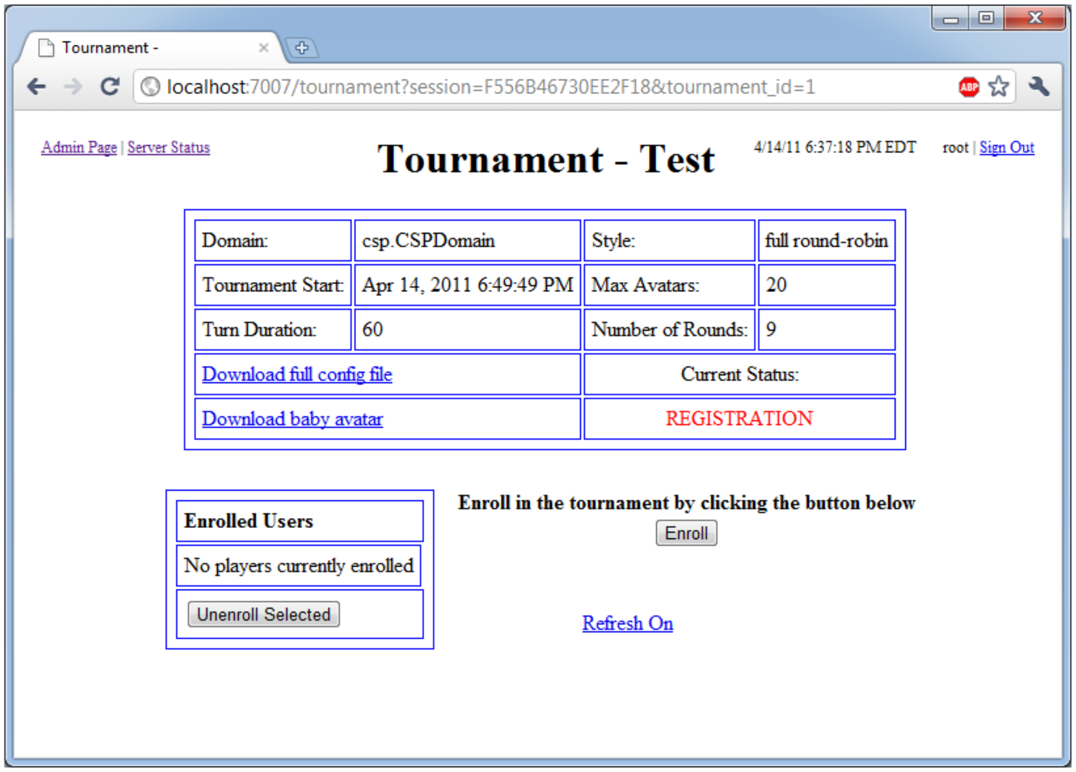
Figure E: The Server Status Page (Administrator View)

6.4. Tournament Status Page

From the server status page, clicking on a tournament ID number will navigate to that tournament's status page. From here, more details regarding a specific tournament are displayed (i.e., the tournament style, the maximum number of avatars, turn duration, and more). Links to download the playground configuration and the baby avatar are also available here.

Like the server status page, individual tournament status pages are also available to both the administrator and regular users. Regular users must sign in and open a particular tournament's status page to enroll in that tournament before registering. While regular users can also unenroll themselves from tournaments that they have previously enrolled in, only the administrator can unenroll any user. Unenroll option will be available only till the tournament is running.

Once the tournament is started (Current Status: RUNNING) at the scheduled Tournament Start time, the users can view the live score updates from this page. The Refresh On option automatically refreshes the page after certain time interval to get the current score. After the tournament is completed, the current status changes to COMPLETED and the final ranking of the avatars will be displayed.


Tournament -
localhost:7007/tournament?session=F556B46730EE2F18&tournament_id=1
Admin Page | Server Status
root | Sign Out
Enroll
Unenroll Selected
Refresh On

Tournament - Test

4/14/11 6:37:18 PM EDT

Domain:	csp.CSPDomain	Style:	full round-robin
Tournament Start:	Apr 14, 2011 6:49:49 PM	Max Avatars:	20
Turn Duration:	60	Number of Rounds:	9
Download full config file		Current Status:	
Download baby avatar		REGISTRATION	

Enrolled Users
No players currently enrolled

Enroll in the tournament by clicking the button below

Figure F: A Tournament Status Page (Administrator View)

6.5. Tournament Setup

Given the explanations of the various components from the previous subsections, using the SCG court system's web interface to create and ultimately run a tournament should be a relatively easy procedure:

Prerequisites

- A sufficient number of users have successfully created accounts via "Sign Up" page (see Section 6.1.1).
- The administrator has successfully accessed the admin control panel (see Section 6.2).
- From the admin control panel, the administrator has successfully created a tournament (see Section 6.2.1).
- Also from the admin control panel, the administrator has successfully approved every user that has created an account in the first prerequisite (see Section 6.2.2).

Steps

- Approved users can successfully sign in via the SCG court system's web interface (see Section 6.1).
- A logged in user is able to observe the server status page, which contains the tournament that the administrator has previously created (see Section 6.3).
- By clicking on the appropriate tournament's ID number, the user is brought to the tournament status page and is able to enroll in the tournament (see Section 6.4).

Once tournament setup is complete, no additional steps are needed on the web interface side. However, users that are enrolled will need to register their avatars at some point once the tournament status has moved from "ENROLLEMENT" to "REGISTRATION". While users can still enroll during this time, they will not be able to register until this change, which takes place approximately 90 minutes before the tournament is scheduled to start.

6.5.1. Registration

The final step in playing a tournament is to register the avatars with the SCG court.

Prerequisites

- The user is successfully enrolled for the tournament and able to download the config and baby avatar from the tournament status page (see Section 6.4).
- The tournament current status should be "REGISTRATION".

Steps

- Run the following command from the console.

```
java scg.net.avatar.PlayerMain <portNo> < hostname > <username> <password> <tournamentID>
```

<portNo>	- valid port number at which the avatar will receive requests & send responses.
<hostname>	- hostname at which the SCG court is running.
<username>	- username provided to login in SCG court web page.
<password>	- password of the user provided to login in SCG court web page.
<tournamentID>	- tournament ID mentioned in Server status web page.

- After running the following command the console should display the success message to indicate the successful registration of the avatar.

The registration status of the avatar can be verified from the tournament status webpage. The users who are successfully registered will have their name (i.e. username) displayed in bold on Enrolled Users list.