Database Systems: Final Project Proposal

Mark Hudnall Sam Konowitch

April 2012

Domain

For our final project, we hope to tackle the domain of athletics software. In particular, we wanted to provide a fitness tracking web application for sports teams. We want to expand our initial fitness tracking vision to fully model a sports team hierarchy (including positions, captains, and coaches). We plan to provide specialized views for coaches, athletes on a team, and independent athletes (not in a sport, but wanting to track fitness regardless) that provide the relevant information for each role in a digestible way.

Key Features

At the base of our application, we hope to provide an easy, web-based system for tracking fitness and workouts. For coaches and athletes, we hope to model a team as close to reality as possible, including relevant team information like positions and captains. Coaches and captains will be able to set workouts for the week, while players can log their progress and view summary statistics. If we have extra time, we hope to expand our fitness tracking and team modeling to include in game statistics, which would be sport specific. We also hope to provide support for professional athletes, who have contracts and receive salaries.

Expected Results

By the end of the project, we hope to present a polished web application. The web application will provide a login system. Coaches register and add players, or players can register as independents. Coaches and captains will have an interface to specify required workouts. Players will be presented with a view of upcoming and previous workouts. Players can log their own progress, as well as view the progress of other members of the team (a team cannot view another teams progress). Coaches will be able to designate roles for players on his/her team, like positions or captain status. This will determine what information players can view in the webapp.

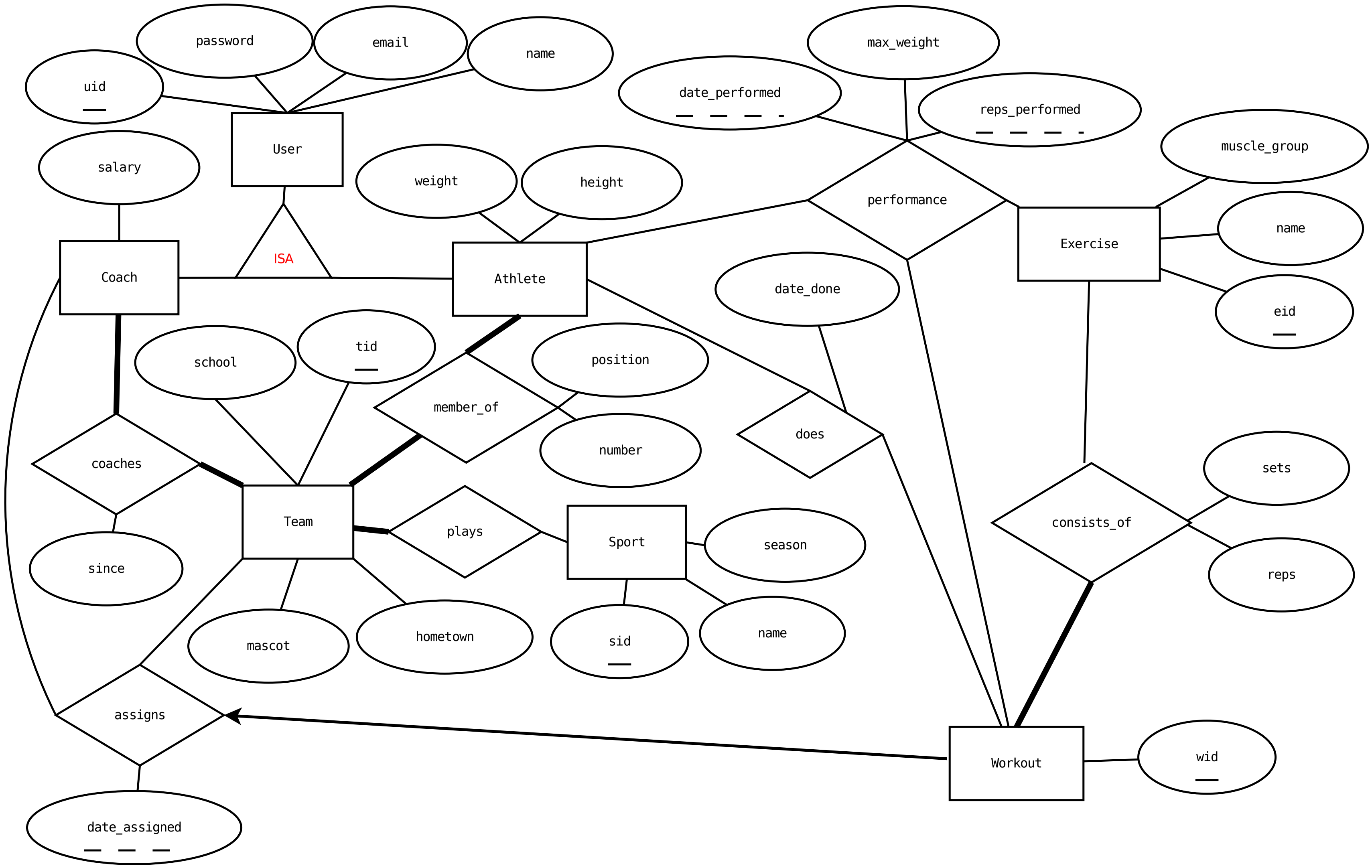
Tentative Schedule

Date	Goal	Status
April 2	ER Diagrams finalized	completed
April 6	Relations finalized	completed
April 9	Normalization complete	completed
April 11	`schema.sql`	completed
April 12	Application scaffolded	completed
April 20	Generated Data	completed
April 23	Database Security and indexing	completed
April 26	Front-end for Coach and Players complete	completed
May 1	App tested and feature complete	completed

Technologies

We plan to use MySQL as our DBMS. We will be using Python as our server side language, for both web development and database interfacing (via the mysql-python module). We are currently planning to use the Flask web framework. We are both comfortable with Python, and the Flask framework is very easy to use, which will let us focus more on the database portion of the assignment. `mysql-python` is essentially identical to `JDBC`.

ER Diagram


password
email
name
uid
User
salary
weight
height
date_performed
max_weight
reps_performed
muscle_group
performance
Exercise
name
Coach
ISA
Athlete
date_done
eid
school
tid
position
member_of
number
does
coaches
Team
plays
Sport
season
consists_of
sets
reps
since
mascot
hometown
sid
name
assigns
Workout
wid
date_assigned

Relational Model

```
User(*uid, name, email, password)
Coach(*uid, salary)
Athlete(*uid, weight, height)
coaches(*uid, *tid, since)
Team(*tid, school, hometown, mascot)
Sport(*sid, name, season)
plays(*tid, *sid)
member_of(*uid, *tid, position, number)
Workout(*wid, uid, tid, *date_assigned)
Exercise(*eid, name, muscle_group)
consists_of(*wid, *eid, sets, reps)
assigns(*uid, *wid, *date_assigned)
does(*uid, *wid, date_done)
performance(*uid, *eid, *date_performed, *reps_performed, max_weight)
```

* denotes a primary key.

1 Functional Dependencies and Normalization

We chose to eliminate as much redundancy as possible in our database and thus chose to normalize our relations to BCNF. We have identified three violations of BCNF in our relational model.

First, let us consider the Team relation. We observed that a team from a given school will have a given mascot (for instance, teams from "Pomona-Pitzer" will have the mascot "Sagehen", while the school "UCLA" will have the mascot "Bruins" for all its teams). Thus there is a functional dependency from school to mascot. Thus we decompose Team into two relations: Team(tid, school, hometown) and TeamMascot(school, mascot). This eliminates the functional dependency in Team. For TeamMascot, we have a FD from school $\rightarrow$ mascot, but since school is a key, the relation is in BCNF. Thus both relations are in BCNF.

Next we consider the Sport relation. We observed that for the sports we deal with, the same sports are always in the same season. Thus there is a functional dependency from a sport's name to its season. Thus we decompose Sport into two relations: Sport(sid, name) and SportSeason(name, season). This eliminates the FD in Sport. SportSeason has a FD from name to season, but since name is a key, SportSeason is in BCNF. Thus both relations are in BCNF.

Our final violation of BCNF is in the Exercise relation. We have a functional dependency from name to muscle_group because we have determined that any exercises with the same name will work the same muscle groups. For example, "bench press" will always work "chest" and "squats" will always work "legs", so we need to decompose this relation to put it in BCNF. The result of our decomposition will be two tables Exercise(eid, name) and ExerciseMuscles(name, muscle_group), eliminating the FD in Exercise and moving it to ExerciseMuscles, where since name is a key, the relation is BCNF.

Thus our final set of relations is:

```
User(*uid, name, email, password)
Coach(*uid, salary)
Athlete(*uid, weight, height)
coaches(*uid, *tid, since)
Team(*tid, school, hometown)
TeamMascot(*school, mascot)
Sport(*sid, name)
SportSeason(*name, season)
plays(*tid, *sid)
member_of(*uid, *tid, position, number)
Workout(*wid, uid, tid, *date_assigned)
Exercise(*eid, name)
ExerciseMuscles(*name, muscle_group)
consists_of(*wid, *eid, sets, reps)
does(*uid, *wid, date_done)
performance(*uid, *eid, *reps_performed, max_weight)
```

Interesting Features

We have several interesting features as part of our application that we wanted to illuminate here.

Stored Procedure

As a general rule, we tried as much as possible to move logic to the database level, rather than the application level. One such example is the stored procedure we used to help calculate, given a team id and workout id, which members of a team have completed a workout and which have not. Here is the procedure:

```
CREATE PROCEDURE TeamProgress (
    IN tid INTEGER,
    IN wid INTEGER
)
BEGIN
    (SELECT M.uid, A.name, FALSE as completed
    FROM member_of M, User A
    WHERE M.tid = tid
        AND M.uid = A.uid
        AND M.uid NOT IN (SELECT D.uid FROM does D WHERE D.wid=wid)
```

```
    )
    UNION
    (SELECT M.uid, A.name, TRUE as completed
    FROM member_of M, User A
    WHERE M.tid = tid
        AND M.uid = A.uid
        AND M.uid IN (SELECT D.uid FROM does D WHERE D.wid=wid)
    );
END
```

When the procedure is invoked, the resulting set of tuples that is returned looks something like:

```
mysql> CALL TeamProgress(1,1);
+-----+----------------------+-----------+
| uid | name                 | completed |
+-----+----------------------+-----------+
| 396 | Sylvester Norman     |         0 |
|  11 | Christopher Anderson |         1 |
|  46 | Henry Campbell       |         1 |
|  81 | Carlos Henderson     |         1 |
| 116 | Vincent Gibson       |         1 |
| 151 | Oscar Palmer         |         1 |
| 186 | Roberto Fox          |         1 |
| 221 | Ron Morrison         |         1 |
| 256 | Dwayne Holland       |         1 |
| 291 | Tracy Holt           |         1 |
| 326 | Angelo Lyons         |         1 |
| 361 | Alton Glover         |         1 |
| 431 | Drew Ballard         |         1 |
| 466 | Dexter Norton        |         1 |
+-----+----------------------+-----------+
14 rows in set (0.00 sec)
```

This stored procedure provides a simple abstraction for our application code, so instead of having to run the query and have complicated looking application code, we simply call the stored procedure and act on the result. We use this procedure heavily for the coach workflow; a coach can quickly see which athletes on a team have and have not completed a workout.

Integrity Constraints

Our ER Diagram shows our initial hopes relating to key and participation constraints. We hoped to enforce: a team has at least one athlete, an athlete has at least one team, a team plays at least one sport, and a workout is assigned by one and only one coach.

We implemented the total participation and key constraint on workouts by merging the "assigns" relationship with the "Workout" table. The other constraints proved trickier, however. We were hoping to use triggers to implement the first two constraints and ensure that they hold with checks, but we ran into a problem. When an athlete registers, the integrity constraint would mean he must also join a team. However, in order to join a team, the `memberof` relation requires a foreign key to the "User" table. We could not figure out a way around this problem, so we omitted the constraint from our schema.

ISA

In our ER Diagram, a "User" ISA Athlete or a Coach. We implemented this in our schema with three separate tables. The "User" table contains a uid, name, email address, and password. The "Athlete" table has a foreign key to "User" on uid, and additional fields for height and weight. The "Coach" table also has a foreign key on uid and an additional field for salary. With our implementation, we allow for Users who are neither Athletes nor Coaches, since we have a separate table for Users.

Security Considerations

Since we were storing passwords in the database, we did not want to store them in plaintext, since if our database were compromised, the attacker could then impersonate any user. Thus, we hashed and salted our passwords before storing them. This was done using a built-in function of the Flask web framework. Thus, a password like `test1234`, when hashed and salted, was recorded in the database as `sha1`$3EZTz7F$`78b2e64a891662a9c5431b6936c35f5740992a708` . Hashing itself adds security. However, only hashing leaves the database vulnerable to attacks using rainbow tables, prebuilt tables that match a plaintext password to its hash. By salting a password, prepending some string to the password before it is hashed, we add an additional layer of security that makes it more difficult to use rainbow tables (since one would need to construct a rainbow table with the salt prepended to every plaintext password, a time consuming process).

Database Tuning

As we built and tested our application, we realized that we were performing several inefficient queries that would benefit from added indexes. In particular, when a coach builds a workout, we built the application so that the coach first chooses a muscle group and then the corresponding exercises were shown. We then use the exercise name to look up the exercise id from the "Exercise" table. In essence, we were actually using the table "backwards", using a field to find the primary key. Both exercise names and ids are unique.

Our decompositions left "Exercise" with a foreign key on *name* to "Exercise-Muscles". We thus added the `UNIQUE` keyword to the *name* field in "Exercise-

Muscles", thus adding an implicit index on the field. This means that queries on *name* will be faster, improving database performance.

We also added the `UNIQUE` keyword to the *email* field of "User". Though it is easiest to refer to users by their ids in urls and queries, a user logs in using his or her email address. Since this is a frequently used feature, we wanted to ensure that looking up a *uid* given an email address would be performant.

Future Work

As we said before, we did not implement all of our integrity constraints that we initially had in our ER diagram, so this would be the top priority for the future. We would either implement this using triggers or by making changes to our schema. There are also queries that we would want to improve the efficiency of our stored procedure.

On the application side, we would want to give users more opportunities to input data, especially at registration. Right now, there is no way to add a new team to the database and when players are added to the database, they do not get to chose their position or number. Our database could easily handle such uses and we did not have time to set up the interface forms for adding this information to the database.