Chess

Gustavo Paz

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1 Introduction

I, Gustavo A. Paz, created a network-enabled Chess game system that can be played through web browsers, securely. Users are able to create accounts, create and join Chess games to play against others, and search for players to see their game history and win/loss statistics.

2 Design Architecture

I broke down the game system into 5 different components. The first was the front-end which was developed with Angular. Next are the two back-end webapp/services/endpoints the front-end communicates with, IAM and Delegate, both developed with NodeJs. Next are the two database systems the services communicate with to store game states and user authentication information, MongoDB and PostGreSQL.

2.1 Front-end Architecture

The front-end was developed with Angular. The front-end was broken down to views, models, and services.

2.1.1 Models

I will start by breaking down the models. Models are considered as plain old objects with a constructor and fields. The first one is the game model, it keeps track of the minimum information to display the game state to the users. Things like the history of moves, the chess board state, the player who's turn it is and so on. Next are the game-row and game-column models. They keep track of the chess board, which piece is in which place. Then the game-history model. This contains the move that users have made for a single game. Then we have the profile mode. This contains the win/loss statistics for a user and their game history. The user model maintains the relevant account session information of the user, such as user-id, username, role, and session token. The validation model is used to determine if validations were returned properly from the back-end services.

2.1.2 Guard Models

Thes are Angular guards that contain logic that should be executed before/after webpages in the application and can be used to re-route traffic.

The exit-history guard ensures the history object in the session storage is removed. The exit-profile guard ensures the profile object is removed from the session storage once the webpage using the guard is left from. The game guard is used to determine if a game object is in the session, then the only webpage that should be visible is the game state webpage. The history guard does not let the webpage from being visited if the history object is not set in the session storage. The linkguard is used for every webpage except the login to determine if the webpage is visible - only true when signed-in. The profile guard only allows access if a profile value is set in the session.

2.1.3 Services

The services are objects in the Angular app that send requests to the back-end services (IAM, Delegate) on behalf of the Angular app. There are two, the iam service and the delegate service.

The iam service only communicates with the IAM back-end service to authenticate and create users. The method createAccount(username: string, password: string) sends requests to IAM to create accounts and sets the user once successful. On failure, the user is not created nor signed in. Next is login(username: string, password: string) which sends requests to authenticate users and sign them in - setting the user object in the session. There is also a helper method logout() which clears all the session information of the user signed in.

The delegate service only communicates with the Delegate back-end service to load and maintain game related information. The loadGameIfExists(user: User) sends a request to the back-end to load the last game the user was in to allow the user to rejoin. getGameState(gameId: string, token: string, userId: number) is used to load the latest game state of a game. createGameState(token: string, userId: number, username: string) is used to create a new game with the user making the request as the player with the white Chess pieces. submitMove(fromColumnId: string, fromRowId: number, toColumnId: string, toRowId: number, gameId: string, token: string, userId: number, username: string) sends the move being made by the user for a specific game to the back-end service. getAllGames(userId: number, token: string) loads the 10 oldest games waiting for players to join. joinGame(gameId: string, userId: number, token: string, username: string, complete: () = void) makes a request to the back-end to set the second player of a game as the user making the request - upon a successful request the complete() method is called. quitGame(gameId: string, userId: number, token: string) sends a request to mark the game as a loss for the player sending the request - upon successful update the game is completed and the other player is marked as the winner. getProfile(userId: number, token: string, username: string, complete: () = void, failed: () = void) makes a request to load the profile for the username parameter - on sucess the complete method is called, on failure the failed method is called.

2.1.4 Views

The views the users interact with are the createaccount, find-game, find-user, game-state, history, login, and profile.

The createaccount view allows users to create an account to play Chess games. It has an input field for the username and password. Once users enter values and click the create account button, the iam service is used to make a request to the IAM webapp to determine if the username is valid - ie: no other user has it - and returns a user with a session token on successful account creation.

The find-game view allows users to look for and join the 10 oldest games waiting for users to join. It also provides a link to allows users to join their last game if the game has not been timed out. This page uses DelegateService.joinGame() to join a game listed if anothe user has not joined; it also uses DelegateService.getAllGames() to load the 10 oldest games.

The find-user view provides a text-field for users to search for other users to then see their profiles. This page uses DelegateService.getProfile() to find and return profiles of valid usernames, if an invalid username is submitted a profile is not displayed.

The game-state view provides an interface for users to view the game state and move piece in the user's current game. This page uses DelegateService.getGameState() to load the game state, DelegateService.submitMove() to submit valid moves, and DelegateService.quitGame() to quit games.

The history view provides users the ability to see the history on a specific game - who moved what and where from/to - the object returned by DelegateService.getProfile() contains the game history information.

The login view allows users to login to their account - IamService.login() is used to log users in.

The profile view displays the game history of users and they're win/loss statistics - the DelegateService.getProfile method is used to load the related information.

2.2 Database Architecture

The two databases I used for the project are MongoDB and PostGreSQL. I used PostGreSQL specifically for the IAM service because authentication information never changes and relation databases provide good storage for data that does not constantly - like the game states. Given the user account information does not change after creation, this type of database was ideal for the IAM service. I then used MongoDB to store game state information. Unlike relational databases NoSQL provides great performance for constant writes and reads which is why I used it to store the game states since they're constantly being updated while games are being played.

2.2.1 PostGreSQL Tables

There are 6 tables used to store and manage user identity information. The first is the permission table, which stores all the permissions roles are given. The role permission table assigns permissions to roles. The role table keeps track of the different roles for the application, for this application there is one, 'Hikaru'. Next is the user role table which assigns users to roles. Next we have the user table which stores the user information such as the username and creation date. Finally we have the user sec table which stores the passwords for accounts and the salts used to generate the passwords. As in the diagram below, there are foreign key, not-null constraints, and unique constraints to ensure the data is consistent.

2.2.2 MongoDB Structure

The database has only one collection which is 'chess'. Entries in this collection keep track of games. The id column is for the game id. It maintains usernames and ids along with the winner's username and id. There is a state column which maintains the state of the board and a fenState column which is used in conjunction with a board validator to ensure the game state and moves are valid. The history column maintains the moves of each player while maintaining the order of said moves - the tracebility of the game. The state field maintains the game as a set of rows with columns with their column id and the piece at each column - directly mapping to the board state users see on the front-end.

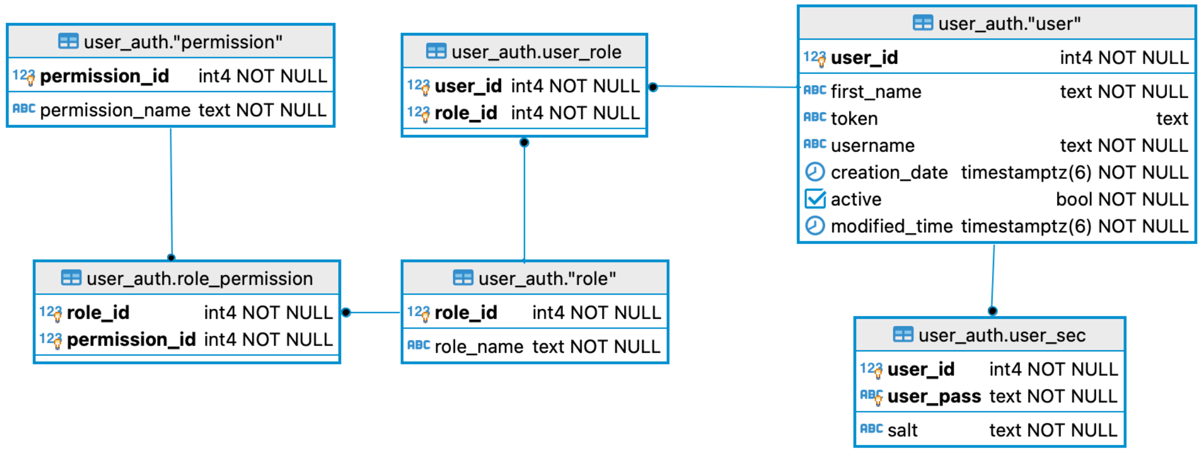

Figure 1: ER Diagram

2.3 Back-end Architecture

The back-end consists of two different NodeJs servers. One is the IAM service, which handles user account identity management. Then is the Delegate service, which handles the game information.

2.3.1 IAM Service

This service is developed in NodeJs and communicates with with the PostGreSQL database.

2.3.2 IAM Service Configuration

The service listens on the 8000 port and uses the express library and cors library to receive requests from the front-end. Express provides a way to easily add POST/GET endpoints to the service. For requests received, I've added the express.json() middleware that only parses json and only looks at requests where the Content-Type header matches the type option - given I only send json type data to this service this seemed fit. Along with this I added express.urlencoded() to the service which parses urlencoded bodies for POST requests this service receives. The cors library provides is a middleware that enables CORS for the service so only GET and POST requests coming from the front-end, specifically 'https://localhost:4200', are allowed. Furthermore the service sets its key, cert, and certificate authority which are used to authenticate SSL/TLS connections from the front-end.

The database connection is also configured and set using node-postgres which is built on top of the built-in TLS library. So when we provide the service certificate, key, and db certificate, the connection is assured to be secure. This library also allows us to set timeouts on query and statement processing to lessen the possibility of hanging requests.

2.3.3 IAM Service Endpoints

First we have the POST endpoint, '/iapi/createaccount'. This endpoint handles the request to create new accounts. It first validates the parameters are not null and valid string values. It expects username and password as the parameters to the request. A salt is then generated with the bcrypt library function genSaltSync() which generates a salt to be used to hash the password. Next a hash of the password is created using the bcrypt's hashSync(password, salt) function. Next it opens a connection to the database and begins a transaction. Once the transaction has started the create user SQL is executed to insert a new user with the username parameter which will return the user id for the new user - the database has a sequence and a unique constraint on the id and username columns to ensure this is no conflicting data. Once the user id is returned the query to insert user seq information, such as the hashed password, user id, and the salt used to generate the hash password are stored so when users try to sign in. Next the role is assigned to the user executing the assgin role query which assigns the 'Hikaru' role. Then a session token is generated using the jsonwebtoken library. The values set in the token are the user id, while only making it valid for 24 hours, and providing the web application certificate to sign it. Lastly the transaction is committed to the database and the new user is returned to the front-end with the token, user id, username, and role. In the event the transaction fails for some reason, the catch clause will rollback any changes that occurred during the transaction.

Second we have the POST endpoint, '/iapi/authenticate'. This endpoint handles all requests to authenticate users trying to sign in the application. Similar to the createaccount endpoint it first validates the parameters are not null and valid string values. It expects username and password as the parameters to the request. Next it opens a connection to the database and begins a transaction. It executes a statement to load the user entry with the same username as the parameter. If an entry does not exists with the same username an error is returned to the application. If it does exist, the salt in the entry is used to generate a hash with the password parameter which is then compared with the hashed password in the database entry. If they are equal the password parameter is correct and the user id and roles are set in the response and a new session token - configured similarly as the createaccount endpoint - is generated for the user. Otherwise these are not set and an error response is sent to the front-end - the user has not been authenticated.

Third we have the POST endpoint, '/iapi/isValidSession'. This is for the front-end to verify the current session token users are using in the application are valid. It expects an id parameter and a token parameter - these two are both validated. Once validated the jsonwebtoken library provides a function to verify tokens by providing the certificate used to create the token and the options provided in the authenticate and createaccount endpoints. If the user id is not equal to the one in the request, the user is not using a valid token and an error is returned, otherwise a valid response is sent back. There is also some logic if the token is expired which forces the user to sign back in once the error response is sent.

2.3.4 Delegate Service

This service is developed in NodeJs and communicates with with the MongoDB database.

2.3.5 Delegate Service Configuration

The service listens on the 3000 port and similar to the IAM service this uses the express library and cors library to receive requests from the front-end. Express provides a way to easily add POST/GET endpoints to the service. For requests received, I've added the express.json() middleware. Along with this I added express.urlencoded(). The cors middleware if configured so only GET and POST requests coming from the front-end, specifically 'https://localhost:4200', are allowed. Furthermore the service sets its key, cert, and certificate authority which are used to authenticate SSL/TLS connections from the front-end.

The database connection is also configured and set using mongodb which is built on top of the built-in TLS library. So when we provide the service certificate, key, and db certificate, the connection is assured to be secure. This library also allows us to set timeouts on the connection and selection processing to lessen the possibility of hanging requests. In addition the max idele time is set which set the maximum number of milliseconds that a connection can remain idle in the pool before being removed and closed.

2.3.6 Delegate Service Endpoints

The first endpoint is '/api/createGame'. This provides the front-end the ability to create a new game for users to join. It takes 3 paramters, the sesssion token, the user id, and the username - which are validated. Once the parameters are extracted from the request, the token is validated. If the token is not valid - validated the same way the IAM service verifies the token; using the web application certificate and ensuring the token has not expired - an error response is returned. Otherwise if the last game the user was in was not finished, it is marked as a loss - since the user is trying to create a new game. Next the game is created with a new game state and is marked as looking for another player. Next the the response is returned with the new game state so the front-end game display the game.

The second endpoint is '/api/gameState'. This endpoint provides the front-end the ability to reload the game state for users. It takes 3 parameters, the game id, the user id, and the token id - which are all validated. The token is then validated - similar to the createGame endpoint. Next the MongoDB is queried for the game with the same id as the game id parameter. If the game does not exist an error response is sent to the front-end. Otherwise the endpoint if the time taken for the current turn has expired, if it has the winner is set as the player waiting for their turn - a race condition is avoided here since the query update does filtering to avoid updating a game state where the current player did submit a move before this query updated the game state; given MongoDB provides monotonic write guarantees. If the game is not timed-out and a player has not joined the game the timer for timing out the user is reset to the current time. Finally the game state is loaded by the game id parameter and returned to the front-end.

The third endpoint is '/api/submitMove'. This provides the front-end the endpoint for users to submit moves to. It takes 8 parameters, the game id, the username, the session token, the user id, and the row and column indices the piece is being moved from and to - all of which are validated. Next the session token is validated - similarly as the previous endpoints. Then the game is loaded from the database to ensure the game id parameter is related to one that exists. Next the game state loaded is updated with the move made. This is move is validated both ensuring the the user moving the piece owns the piece - ensuring the white piece player is not moving a brown piece - and also ensuring the piece being moved is a valid chess move - a pawn is not making a rook's move - which is done using the chess.js library. Next the game history is updated to keep track of the moves made by players. Next the endpoint uses the chess.js library to check if the game is in a checkmate situation in which the game is over and the last player to move is the winner - the user that just submitted the move. Finally the game in the database is updated with the new game state, history, and winner - if set. Then the game is returned to the front-end with the updated game state.

The fourth endpoint is '/api/getAllGames'. This provides the front-end the ability to load the 10 oldest games waiting for users to join. It takes 2 parameters, the session token and the user id - both which are validated. First the token is validated - similar to the other endpoints. Next the 10 games are loaded and finally returned to the front-end. If games do not exist, an empty objec is returned.

The fifth endpoint is '/api/getLastGame'. This provides the front-end the ability to load the last unfinished game a user was in. It takes 2 parameters, the session token and the user id - both which are validated. First the token is validated - similar to the other endpoints. Finally the game is loaded and finally returned to the front-end. If a game does not exist then an empty object is returned.

The sixth endpoint is '/api/joinGame'. This endpoint provides the front-end the ability for users to join games waiting for players. It takes 4 parameters, the session token, the game id, the user id, and the username - all which are validated. First the token is validated - similar to the other endpoints. Next the last games the user making the request was in are set as losses since the user is attempting to join a new game. Then the game with the same id as the game id parameter is updated if another user has not already joined - again guranteed given MongoDB provides monotonic write guarantees. If the game is sucessfully joined the game state related is returned to the front-end; otherwise an error response is returned.

The seventh endpoint is '/api/quitGame'. This provides the front-end the ability for users to quit games. It takes 3 parameters, the session token, game id, and the user id - which are all validated. First the token is validated - similar to the other endpoints. Then if the game has not started the game is deleted from the database - again guranteed given MongoDB provides monotonic write guarantees. If the game has already started the user that is currently quitting the game is marked as the loser in the game state entry and then the game is returned to the front-end. If the application fails to update the game state then the other player has quit the game before the one making this request, and in this case an error response is returned to the front-end.

The eigth endpoint is '/api/getGameProfile'. This provides the front-end the ability for users to load game profile for users - themselves and others - which contains their win/loss statistics, previous games, and their game state history. It takes 3 parameters, the session token, the user id making the request, and the username we're looking for - which are all validated. First the token is validated - similar to the other endpoints. Next the games the user with that match the username parameter are loaded. The wins and losses are then calculated. Then the profile object is configured and returned to the front-end. If matches do not exist for a user matching the username parameter, an empty object is returned to the front-end.

3 Installation Instructions

4 Operation Instructions

5 Game Rules

Referencing: https://www.chess.com/learn-how-to-play-chess.

This is a board game on a 8x8 board. The pieces start off with pieces on the first and second row. The first row starts off configured with the rook as the first piece of the row, then the knight, then the bishop, then the king, then the queen, then bishop, knight, and rook - completing the first row. Then the second row is full of pawns. The last 2 rows will mirror the first two rows. The goal of the game is to capture the other player's king - capturing is done by moving one's piece onto the same position as the king without another piece intervening nor the king moving from its position.

Each of the these different pieces have their own move patterns. The king is able to move left, right, up, down exactly one space. The king has a special case in which it must be moved or protected when it is in check - indicating the king can be removed by another piece. The queen is able to move however many positions across the board diagonally, up, down, left, or right as long as it does not jump over pieces. The rook can only move up, down, left, or right as many postitions as long as it does not jump over pieces. The knight may only move to positions that are 2 positions left/right and 3 positions up/down or 2 positions up/down and 3 positions left/right away from its current positions. The bishop may only move diagonally and only on positions that have the same color as the one it started on - guaranteed by the diagonal only move constraint - and it cannot jump over other pieces. Finally the pawn may move forward 2 positions on its first move if it does not jump over other pieces. Otherwise it may only move 1 poisition forward and has the ability to move diagonally forward 1 position only if it is removing another piece.

6 Why is it secure?