Technical Report - **Product specification**

KeyUsageProfiler

Course:	IES - Introdução à Engenharia de Software
Date:	Aveiro, 18-12-2023
Students:	107449: Miguel da Silva Pinto 108287: Miguel Belchior Figueiredo 108636: João Pedro Duarte Dourado 110056: Ricardo Manuel Quintaneiro Almeida
Project abstract:	Monitoring of key stroke presses and gathering of statistics around them

Table of contents:

1 Introduction

KeyUsageProfiler is a web-application that allows a user to build teams and gather statistics about their team's keyboard usage. KeyUsageProfiler aims to simplify the supervision of various developers in a software development context by using a keylogger that sends to the team leader not only the key inputs of each member but also notifications about the inactivity of his members.

In the following chapter we'll go into more depth into the development of the product specification by analyzing use cases, creating personas and main scenarios, and developing user stories. According to these requirements an architecture will also be chosen. The product will be implemented following collaborative agile work practices and using GitHub as a code repository and project management system.

2 Product concept

Vision statement

Our project focuses on developing a keylogger that tracks the inputs of various keyboards and stores usage data for each user. This data is given to the user through a web page according to the user 's authorization. If the user is a team leader, he will have access to all the team members' information. However, each team member will only have access to self-related data and a leaderboards table if the team leader decides so.

This system was idealized mainly to help users obtain statistics about their typing data, which can be done as a self-evaluation, comparison between peers or as a monitoring tool for a manager in a company. The last one is more business oriented, allowing a visualization of workers' performance.

Use Cases

Actors:

1. Registered User
2. Team Member
3. Team Leader

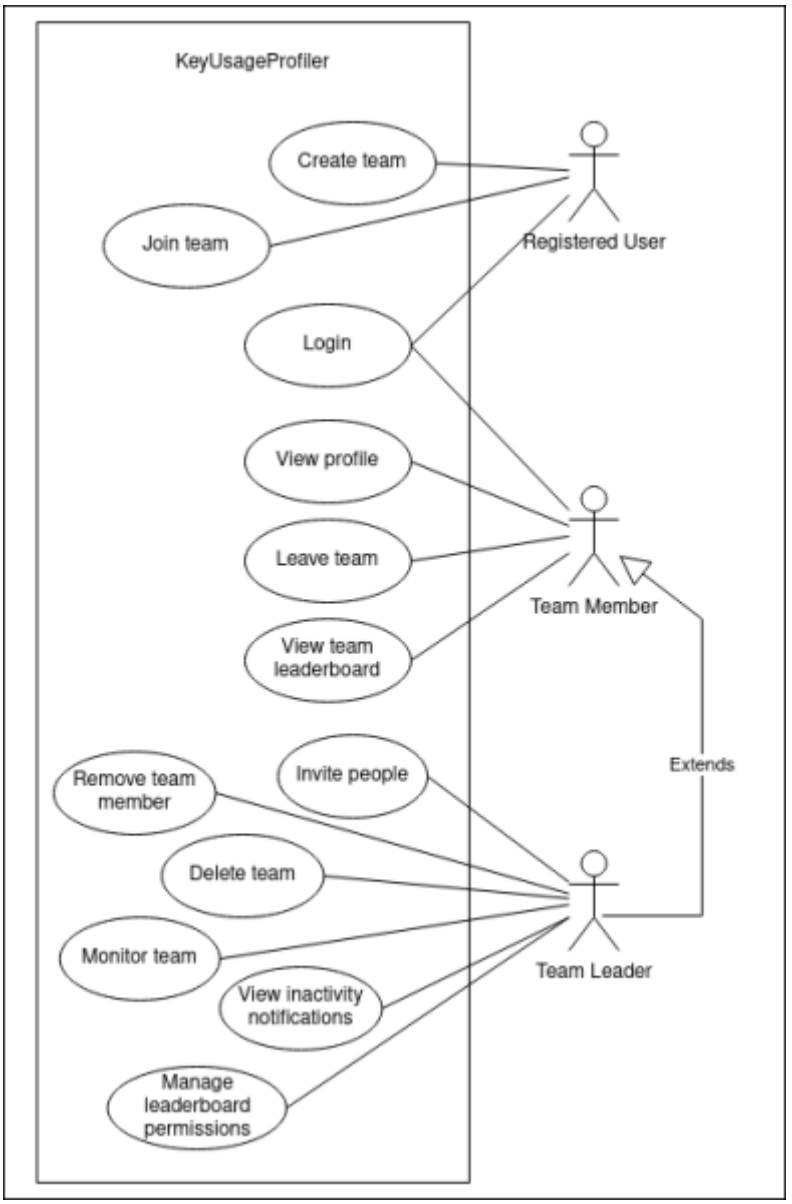


Image 1 - Use Case Diagram

Use Cases for Registered User:

1. **Create Team:** A Registered User can create a new team.
2. **Join Team:** A Registered User can join an existing team.
3. **Login:** A Registered User can log into their account.

Use Cases for Team Member:

4. **Login:** A Team Member can log into their account.
5. **View User Profile:** A Team Member can view their own user profile.
6. **Leave Team:** A Team Member can leave the team they are a part of.
7. **View Team Leaderboard:** A Team Member can view the leaderboard of their team.

Use Cases for Team Leader (Extends Team Member):

8. **Invite People:** A Team Leader can invite other users to join their team.
9. **Remove Team Member:** A Team Leader can remove a team member from the team.
10. **Delete Team:** A Team Leader can delete the entire team.
11. **Monitor Team:** A Team Leader can monitor the team's activities and performance.
12. **View Inactivity Notifications:** A Team Leader can receive and then view notifications based on Team Member's lack of activity.
13. **Manage Team Leaderboard Permissions:** A Team Leader can manage permissions related to the team leaderboard.

Personas

There have been defined two main actors for this system: **Team Leader** and **Team Member**.

Edward (Team Leader) – a 51-year-old, male, development team leader and SCRUM master.

- **Actor**: Team Leader
- **Motivation**: Wants to get a general and detailed view of the developers' performance in his team.
- **Requires** a service that gathers and presents relevant information about his overall team and each member when it comes to coding time per workday.

Emily (Team Member) – a 23-year-old, female, university student

- **Actor**: Team Member
- **Motivation:** Wants to compare her typing skills with her friends and compete with them.
- **Requires** a service that collects the typing data while she writes her essays and summarizes it while also allowing for a competitive view between the people in her friends group.

Main Scenarios

Monitoring team member's productivity

Edward has been noticing a decline in productivity in his team members and wants to monitor their productivity. So, in KeyUsageProfiler, he creates an account and subsequently a team, and invites his colleagues to the team to **see keypress statistics while at working hours**. He can also have a **more detailed view by checking certain patterns** (team members might be gaming at work) and **be notified of the user's inactivity**.

Competing with peers

Emily is focusing on **competing with her friends to see who has the fastest typing speed**. To do that, she **receives an invite link for a team** in KeyUsageProfiler from one of her friends. Then she will install the program and run it with her credentials. After that, she will regularly **check the leaderboards** to see who is on top.

Distributing workers in a project

Edward divided the team and distributed the tasks for the day. To guarantee that each group progresses at the desired rate he **watches each group's statistics separately**. Then he can allocate new members to the group that's underperforming.

Helping team member's setup an environment

Edward is responsible for assuring that new members of a team can set up their environment to start development. With that in mind he checks for **team members that use the same IDE** as the new member and asks those members to help the newcomers with the setup process.

Product requirements (User stories)

We identified 3 agile epics that encapsulate sets of related user stories - **user authentication**, **team management** and **statistics gathering and presentation**.

User authentication:

User Story 1: User login

As a registered user
I want to log into my account on the website
So that I can see my user profile and the team I belong to

User Story 2: User Registration

As an unregistered user
I want to create an account in the website
So that I can access the website features

Team Management:

User story 1: Create Team

As a registered user
I want to access the homepage
So that I can create a new team

User story 2: Invite Team Members

As a Team Leader
I want to create invite links
So that I can assign different people to a team

User story 3: Become part of a Team

As a registered user
I want to accept an invite link
So that I can become part of the corresponding team

User story 4: Remove team member from team

As a Team leader
I want to access a team management menu
So that I can remove a team member from the team

User story 5: Leave current Team

As a team member
I want to exit my current team
So that I can join another team or create my own

User Story 6: Delete Team

As a Team Leader
I want to delete my team
So that I can join another team or create another one

Statistics gathering and presentation:

User story 1: Key Heatmap

As a Team Leader

I want to select a development team member

So that I can monitor the developer's performance by tracking the average key presses and visualizing it with a heatmap

User story 2: User Profile Statistics

As a Team Member

I want to go to my profile page

So that I can view how much time I spent typing, my average type speed and my peak typing time

User story 3: Activity Analysis

As a Team Leader

I want to see if a team member is gaming or coding

So that I can analyze if my team members are working or not

User story 4: Live Virtual Keyboard

As a Team Leader

I want to access a live representation of what a Team Member is typing

So that I can monitor the developer's real time activity on the keyboard

User story 5: Estimation of IDE or editor

As a Team Leader

I want to identify what editor are my Team Member's using when they are coding

So that I can know the IDEs used by my team

User story 6: Leaderboards

As a Team Leader

I want to access a dedicated leaderboard page,

So that I can conveniently track and compare team members' average typing speed and other useful statistics

User story 7: Leaderboard Permissions

As a Team Leader

I want to access the leaderboard settings
So that I can limit leaderboard visibility by team members

User story 8: Dashboard Members Selection
As a Team Leader
I want to select multiple team members
So that I can monitor their information as a group

User story 9: Reset Team Statistics
As a Team Leader
I want to reset the key stroke statistics of my team members
So that I can re-evaluate performance in a new agile sprint

User story 10: Reset Statistics Periodically
As a Team Leader
I want to reset the key stroke statistics of my team members periodically
So that I can evaluate performance in each agile sprint

User story 11: Inactivity Notification
As a Team Leader
I want to be notified when team members are inactive
So that I can keep my team productive during work hours.

User story 12: Last pressed keys
As a Team Leader
I want to see what a Team Member is typing
So that I can monitor the developer's real time activity on the keyboard

3 Architecture notebook

Key requirements and constraints

KeyUsageProfiler is a **service with a web interface** that displays statistics about a team's keyboard usage. Some of these statistics like average words per minute, maximum words per minute and time spent typing require processing and others like the virtual live keyboard can automatically be displayed without any need for it. With this in mind, it makes sense for the latter to be directly fed to the webapp while the first passes through the required processing channels. But there is a catch: the data behind all features is the same (the keystrokes).

Implementation regarding the keylogger should be straightforward (collecting keystroke data), except if the need comes to support several alphabets and/or keyboard layouts.

Performance issues are a major concern: since data will be generated at a rapid pace, from every keystroke of every team member, performance should be kept in mind during architecture design. It certainly does not make much sense to insert data in the database on a per-key basis, otherwise there will be a transaction made in the database for each key pressed.

Here are some key requirements and system constraints that have a significant bearing on the architecture of *KeyUsageProfiler*:

- User Authentication and Authorization must be correctly implemented, so that each user only has the necessary permissions to perform their actions and cannot access sensitive data from other users when that was not intended.
- To key log information, for educational purposes we'll only have to pass the user id of the member who's typing. Their keypress data will be passed through a Message Queue, with information related to the key, if it was pressed or released, who pressed it and when it was pressed (timestamp).
- Live keyboards should update in real time with data from a socket connection related to users pressing keys, and display (as a string) what the user is typing. There should be low latency, hence the use of sockets.
- Write performance will be an issue if we insert every keystroke into the database every time it is pressed, since it would result in a lot of transactions. To prevent this, we should buffer keystrokes and insert them according to a predefined timeslot (in a multiple value insert).
- Using such data, the system should be able to generate statistics that may be presented to the user (according to access control policies) as key heatmaps, charts and drawings (e.g. visual representation of the keyboard).
- After receiving and processing the data from the Message Queue, to be displayed at any time in the future, it should be stored in a database.

- There should be a REST API to allow the data to be displayed in JSON format and to be requested by the webpage when it needs it. The API should also allow the webpage server to send data generated on the webpage.
- User inactivity will be detected using a cache database and Spring Boot. A key will be associated with a user, and when it expires, it will generate an event that will be detected by the spring boot backend. Those inactivity notifications will be passed to the frontend through websockets and saved into the persistence database.
- To avoid filling up the database with unneeded data, when a team is deleted (allowed to Team Leaders only) all team related keystroke data should be erased from the database (keystrokes, user statistics and notifications of the former team members).

Architectural view

The architecture planned for the KeyUsageProfiler consists of:

Keylogger

- Takes key press data from users and feeds the Keystroke Distributor with it.

Keystroke Distributor

- Responsible for distributing the keypress data to components that want it, such as the Live Keyboard and the Keystroke Consumer.

Spring Boot

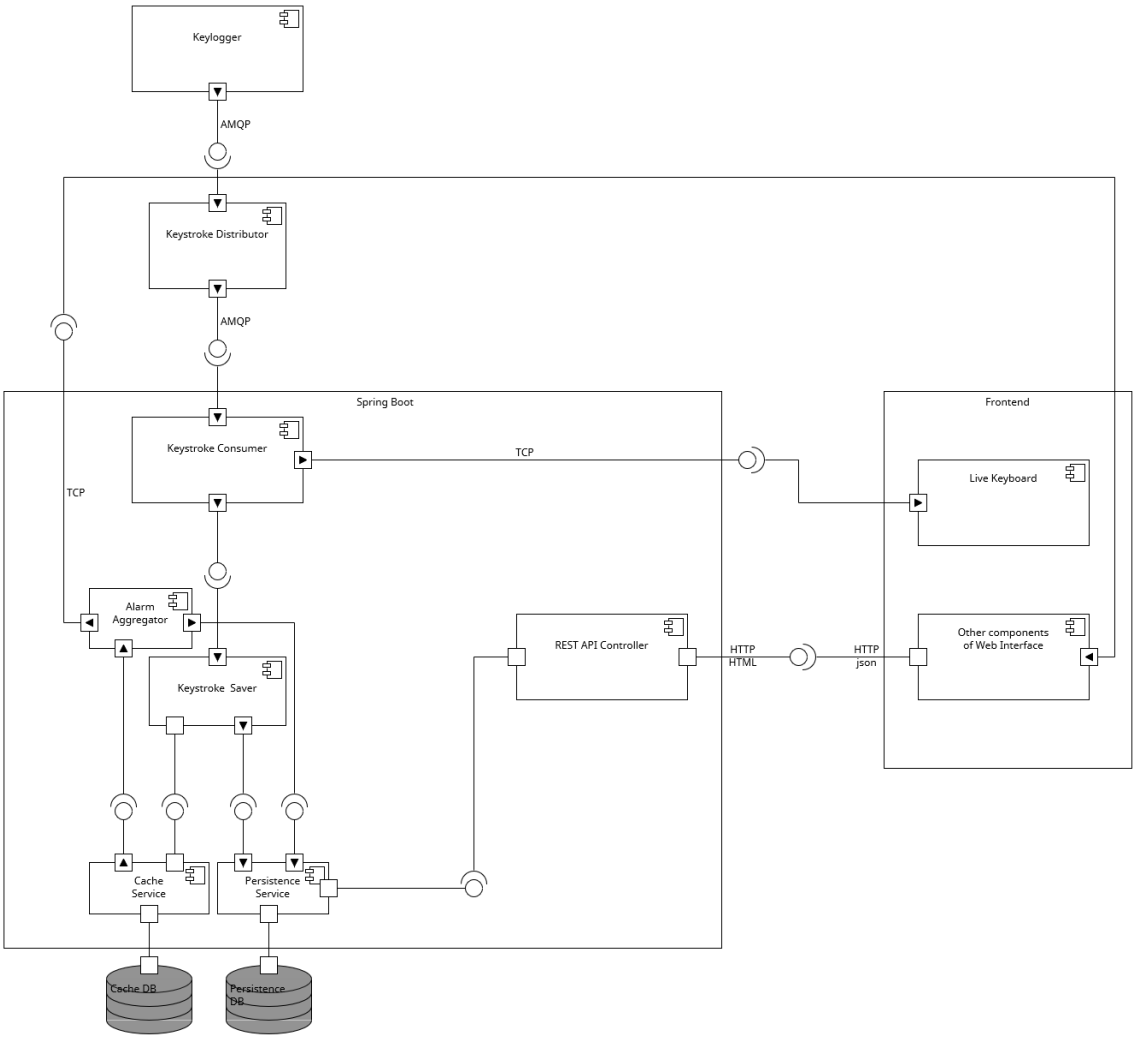
- Keystroke Consumer: Receives keypress data from the Keystroke distributor and passes that information to the Keystroke Saver and to the Live Keyboard.
- Keystroke Saver: Uses the interface provided by the Persistence Service and the Cache Service in order to cache keystrokes or save them persistently to the database, respectively.
- Persistence Service: used to interact with the persistent database. Responsible for saving keystroke data and calculating and saving statistics about that data.
- Cache Service: used to interact with the cache database.
- REST API: Serves the frontend services with information about the system, such as user information, statistics and keystroke data.
- Alarm Aggregator: gets information from the cache database about user inactivity. Uses this information to send alarms to the GUI and saves these notifications in the persistence database.

Databases

- Cache Database: Database used to store keystrokes being pressed and cache those for a period of time, so that they can be then flushed to the persistence database. Used to detect user inactivity (or improper activity like gaming) and “notify” the Alarm Distributor about it. Also used to save short-lived invitation links (that will expire after a certain period of time).
- Persistence Database: Database which will store all data that is meant to be permanent and upon which most queries will be made to show the key stroke statistics. Information saved includes: login information, notifications, statistics and teams.

Frontend

- Live Keyboard: receives keystroke information from the Keystroke Distributor and shows them in real time on a graphical keyboard.
- Other components of the web interface: get desired information from the REST API and display it in the respective components.

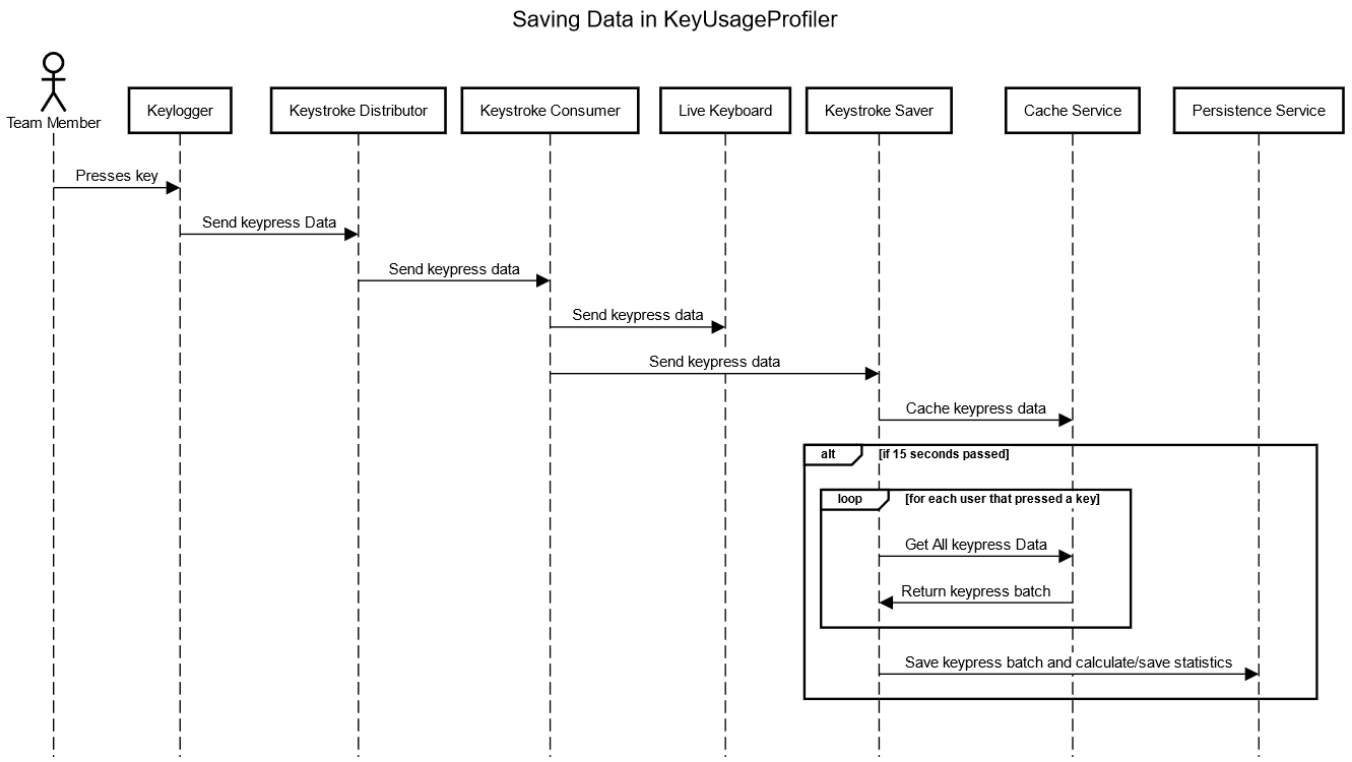


Module interactions

We will split our module interactions into 2 main interactions:

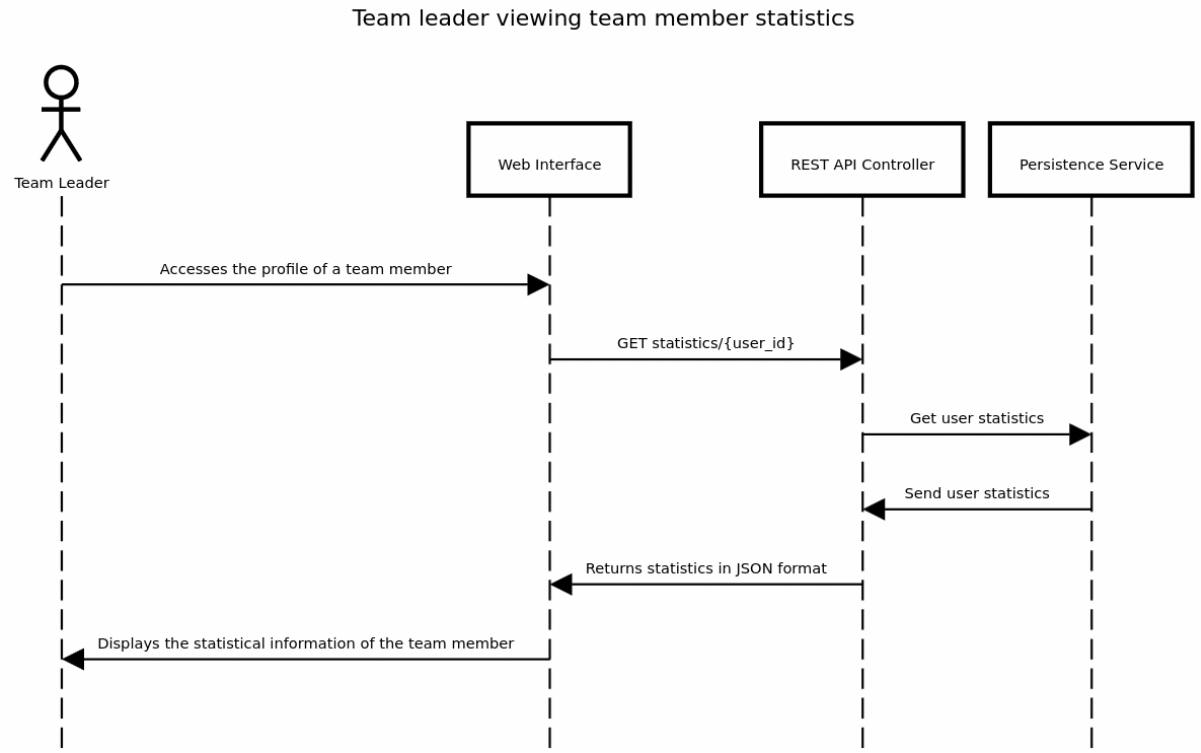
1. **Saving Data in *KeyUsageProfiler***

- A Team Member with the service running presses a key. That data is sent as an event to the Keystroke Distributor.
- The data is obtained by the Keystroke Distributor which sends it to the Keystroke Consumer.
- The keystroke consumer sends the obtained data to both the Live Keyboard and the Keystroke Saver.
- The latter caches the data (through the Cache Service). Every 15 seconds, the keystroke Saver is also responsible to flush this data to the Persistence DB (through the Persistence Service) and calculate/save statistics related to the last sent keystrokes.



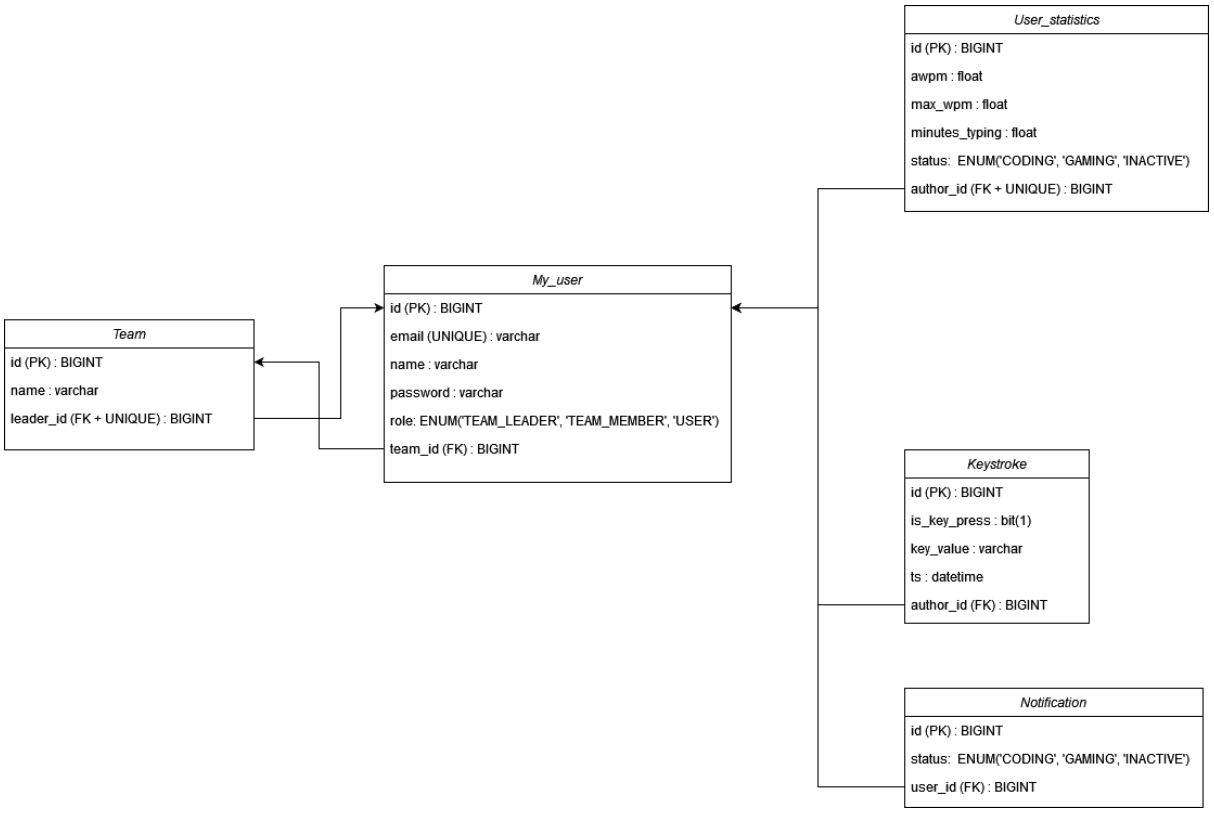
2. **A Team Leader viewing a team member's statistics.**

- The Team Leader accesses the profile of a team member through the dashboard or a link.
- The Web Interface as it loads the page contacts the REST API Controller and asks for the statistical information of the team member in question by using the team member's id.
- After receiving a request from the web interface, the REST API Controller requests the needed data from the Persistence Service.
- The Persistence Service sends the requested data to the REST API.
- The REST API Controller finally returns the statistical data in JSON format to the Web Interface.
- The Web Interface displays the team member data to the Team Leader.



4 Information perspective

We used a **MySQL** database to manage the data used by our system. These are our entities and their relations:



The user is the main entity that relates to all others.

- A user must belong to a Team and relates to it through the **team_id** attribute. In the same way, a Team must have a leader which is a User, related by the **leader_id** attribute (this attribute is unique, since a User can only lead a single Team).
- Keystrokes are related to Users that produced them and they are related to the User by the **author_id** foreign key.
- User statistics are related to Users and describe relevant statistics: average words per minute (*awpm*), maximum words per minute (*max_wpm*), minutes spent typing (*minutes_typing*) and current *status* (“CODING”, “GAMING”, “INACTIVE”). This data relates to the User with the **author_id** and is unique since users can only have a single instance of statistics.
- Lastly, Notifications are related to Users by the **user_id** foreign key, and keep information related to what caused the notification, the User status (keep in mind that in the current vision of our system ‘CODING’ doesn’t produce an alarm/notification, only the other 2 values of the enum do).

We used a **Redis** database to buffer keystrokes, manage short-lived data used by our system like invitation links to join a team (that expire after a certain amount of time) and to notify our application of user's inactivity (user that has sent no keystrokes in a defined amount of time). Both of these last two were implemented with the redis expire command.

The following key-value mapping is present in our redis database:

- **ttl:user_id** - the time to live property of this key is the remaining time for a user to be considered as inactive. When the key expires an Event Listener will send a notification regarding the user as inactive;
- **invitetoken:team_id** - the time to live property of this key is the remaining time for the link to be invalid. The value of this key is the token itself which is built using the timestamp of creation, a random UUID and the team_id. On the one hand, because the invite token is created by **team_id** it is intuitive to override the token (when the user asks to create a new link). On the other hand, because the invite token contains the **team_id** is also easy to fetch for the invite token saved in the database, compare it with what it was in the request and make a decision (user joins or doesn't join the team);
- **user_id** - list with the buffered keystrokes for the user with id **user_id**.

5 References and resources

Backend:

- JWT in Spring
- Good practices for JWT refresh tokens

Frontend:

- React App
- Tailwind
- DaisyUI
- Remix Icons
- Javascript libraries (used for keyboard, heatmap, charts)
- Java library for keylogger (JNativeHook)