



**FACULTY  
OF MATHEMATICS  
AND PHYSICS**  
Charles University

## **BACHELOR THESIS**

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# **Web application for swimming competitions management**

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Study programme: Computer Science

Study branch: Software and Data Engineering

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Sth

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Dedication.

Title: Web application for swimming competitions management

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Abstract: The goal of this work is to create a system that facilitates management of swimming competitions in the Czech Republic. This system must contain necessary infrastructure with easy-to-use web interface that is also mobile friendly. SwimmPair is using MySQL database for storing data, extensible PHP managers for performing all backend tasks. Frontend is implementet via custom drag'n'drop DOM API in JavaScript.

Keywords: key web application, web, automation, catalogization, administration, cms, full stack, frontend, backend

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# Introduction

As someone born in the mid-1990s, I've had a front-row seat to the evolution of personal computing and the rise of the internet. Even as a three-year-old, I was captivated by my father's first computer, which ran Windows 98. By the age of five, I already knew I wanted to be a programmer when I grew up, after realizing that I could write code and create public websites. Over time, I became increasingly fascinated by the stories of technology giants like Microsoft and Apple, who brought computers to our desks and smartphones to our pockets. Of course, my interest in the IT world runs much deeper than this brief overview can convey.

## Why web applications

The dot-com bubble crash in the early 2000s marked a necessary correction of the overhyped optimism surrounding new technologies, helping the industry as a whole to mature. However, it was the financial crisis of 2008 that truly opened up opportunities in the web space. While it left the average American customer poorer, it also spurred a new trend of money-saving services designed to help people cut costs or earn extra cash. Suddenly, instead of calling a taxi, people could use Uber to find a ride from an independent driver. And if they had a spare room, they could list it on Airbnb to make some extra money. Meanwhile, the lack of trust in the banking industry and monetary policy gave rise to Bitcoin and other cryptocurrencies. While some of these innovations may seem technically complex, a skilled software engineer could deploy a minimum viable product of each one in just a matter of weeks or months.

## Motivation

I designed this thesis as a full-stack web application for a friend who works as a chief swimming referee and club manager, in order to help him save time for more important tasks. The process of developing this application has been invaluable training for me, as it required me to devise a solution to a problem that was similar in some ways to the minimum viable products mentioned earlier. Throughout this project, I gained a wealth of experience, insights, and lessons that I hope to apply in my future endeavors and career. As I see it, software engineering is a crucial craft for effecting positive change in the contemporary world. Building new things is an exciting adventure that holds endless possibilities.

Software engineering is a crucial craft for effecting positive change in the contemporary world, as it enables us to create new tools, platforms, and experiences that make people's lives easier, more productive, and more fulfilling. In a sense, building things has become a modern adventure, filled with opportunities to innovate, explore, and improve the world around us.



# 1. Status quo and solution

In this section, we will describe the problem we aim to address and present our proposed solution in the form of an application design.

## 1.1 Problem description

A friend of mine recently asked me if I could help him automate part of his work agenda. Administration of swimming competitions and creating statistics is very repetitive and error-prone array of tasks. All the tasks are executed in the same and straightforward order.

The Czech Swimming Federation <sup>1</sup> structure has to be layed out and subsequently modeled as objects in the application and interface with database via managers (ie. APIs for the application). Thus, a logical structure has to be layed out and implemented.

Swimming referees belong to clubs. Clubs are located in geographical regions. Swimming cup is hosted by a club. Each club contains dozens of swimming referees and one of them must be a club manager. Once a cup is scheduled, referees can sign up to make themselves available for it. Club manager can also sign members of his club up to be available for a cup. At the end of the day, the cup organizer assigns referees to specific task-related positions based on their availability and suitability.

The chairman of referee committee (my friend) should be able to perform additional administration related to the whole dataset - be it adding and removing users, creating new clubs and modifying whole structure. Administrator can also notify all visitors by posting news displayed on homepage.

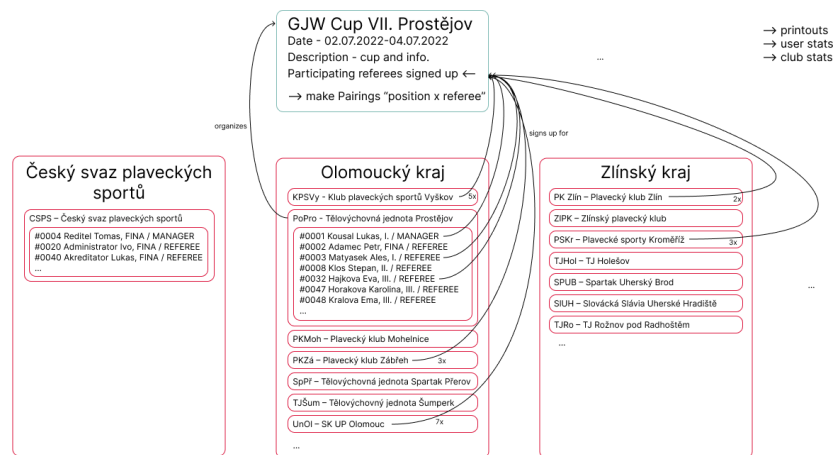


Figure 1.1: Preview of region-club-user grouping & availability for the cup.

The SwimmPair application should deliver public listing of all **users**, **cups**, **news**, **individual statistics** and **club statistics**. Application should allow to browse statistics on yearly basis. Structure (Figure 1.1) then has to be appropriately modeled as entities (Figure 1.2). Proposition of entities-objects mappings (Figure 2.6 Figure 2.7) and database (Figure 2.8) will be shown further down.

<sup>1</sup><https://www.czechswimming.cz>

## 1.2 Stakeholders

Groups directly and indirectly interested in existence of this application and breakdown of its active/passive users.

### Interest groups

There are several entities that are interested in existence of this application. All these stakeholders will have their job facilitated and better organized to some extent thanks to existence of this application.

Interested stakeholders are:

- **Czech Swimming Federation** - organization for competitive swimmers,
- **Olomouc Region, Zlin Region** - CSF regions administered together,
- **Lukas K.** from **TJ Prostějov** - coordinator who asked for this application.

### Users of application

Users of our application will be Czech Swimming Federation members. If their **region is participating in this application**, clubs and referees from this region must be in our system. Depending on their rank within the structure, individuals will be assigned one of these roles:

- **system administrator** (~1-3),
- **club manager** + also a swimming referee (~10s),
- **swimming referee** (~100s).

Roles are self-descriptive. The coordinator (my friend), who came up with this idea for this application will be **system administrator** because he's been running all this agenda in Excel spreadsheets. **Club managers** are taking care of competitions on behalf of their club and **swimming referees** are common people who have some degree of knowledge about competitions and can participate as referees.

The collected statistics will be used for accreditations granting, monitoring activity, and overall categorization.

We iterated requirements and features for this application with two coordinators (two future system administrators) during the time of development.

After finishing we performed test usability on **all three groups of users** via. SUS <sup>2</sup> questionnaire. We then version controlled, unit tested and CI pipelined <sup>3</sup> our application. Despite advancements in automation, deployments are still performed manually.

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<sup>2</sup>**System Usability Scale** is a questionnaire to reveal how friendly tested system is to target audience. We carried on initial testing for 20 people belonging to one of these 3 categories to find out if we met at least an average score which was determined to be 68/100.

<sup>3</sup>Brief overview of CI/CD pipelining <https://resources.github.com/ci-cd/>

## 1.3 Functional requirements

There are areas of similar tasks that we would like address and solve by our application by implementing features and ui pages for these purposes.

### ”C” as Cup administration

1. [club manager] needs to [create swimming cup] in order to [publish cup and invite others to participate]
2. [club manager] needs to [create pairing for swimming cup] in order to [finalize preparations of the cup the day before it takes place]
3. [club manager] needs to [preview cups and print pairing] in order to [perform inspection and publish information offline]
4. [club manager] needs to [participate in cup or participate with teammates] in order to [help swimming cup to take place]

### ”R” as Referees administration & overview

1. [club manager] needs to [manage swimming club] in order to [keep information and users up to date]
2. [club manager] needs to [perform referees managment] in order to [keep referees up to date]
3. [referee] needs to [view statistics of referees] in order to [have track record about personal participation]
4. [club manager] needs to [view statistics of clubs] in order to [have information about performance within his own club]
5. [club manager] needs to [perform club managment] in order to [keep own club up to date]
6. [system administrator] needs to [manage referees] in order to [add, remove, update users in the dataset]
7. [system administrator] needs to [list referees overview] in order to [see activity of referees]

### ”S” as Stakeholders interests

1. [system administrator] needs to [have overview of clubs] in order to [be informed about various things]
2. [stakeholder] needs to [have overall categorization of federation] in order to [use application for administrative purposes]
3. [stakeholder] needs to [have database archivation of federation] in order to [use application as archivation tool]

4. [stakeholder] needs to [have information about participations] in order to [grant accreditations to referees for next season]
5. [system administrator] needs to [publish news] in order to [notify everybody about important things happening]
6. [system administrator] needs to [edit page/s] in order to [change static public info in the application]

## 1.4 Domain model

Let's look at the entities which have to be represented in our system one by one - starting from the most important ones. We will outlay entities and their relations. After basic idea of entities and their relations is established we proceed to project specification to delve further into implementation details. Our approach was, however, more iterative - this retrospective domain model represents only a snapshot of the implementation details that we were specifying throughout the development process.

### Cup

**Cup is the most important entity.** A swimming **cup** contains name, description, date and is affiliated to organizing club. Cup serves two purposes. **Firstly**, referees assignment for specific tasks (time tracking, computer support, main organizer, etc.) has to be **ready by the time the event takes place**. **Secondly**, statistics summing up participations of referees and clubs have to be calculated for each year from all cups in this time period. We also have to discriminate between upcoming and already past cups. Upcoming cups should be displayed, past cups should reside in archive to be revisited for statistical purposes.

### Referee

Referee is a person and main workforce during swimming cup. A referee is a member of a club who participates on the club's behalf in cups. A referee's level of expertise is described by one of several ranks<sup>4</sup>. Referee is assigned to one or more Positions, such as **Timekeeping** or **PC Support** and is in charge of the task for duration of the cup.

### Club manager

Club manager is usually one person who is in charge of club administration. Club manager organizes cup on behalf of club and acts as main figure during it. Club managers may also assist with certain tasks, but their role is primarily administrative. The club manager is responsible for pairing referees with suitable positions and creating work schedules for all participants.

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<sup>4</sup>**Referee Rank** - 1/2/3/4/FINA - <https://www.czechswimming.cz/index.php/rozhodci>

## Coordinator

The coordinator is the head of swimming in a specific region. They prepare budgets, plan tournaments, and manage the administration and database of referees, clubs, and cups. They are the most important person in the administrative hierarchy of swimming.

## Club

A club is an administrative unit that groups people together in the same city. The club has a specific name, abbreviation, and id in the Czech Swimming Federation, and a club logo can be included as well. The club serves as the formal authority organizing the cup by a user who is the club manager. The club is affiliated with the region. Performance statistics of members of the club at swimming competitions must be implemented. These statistics have an informative character and will save time compared to the current status quo of keeping track of presence and work descriptions in Excel spreadsheets.

## Region

There are 13 regions in the Czech Republic, and we are currently addressing this problem for two regions that are being administered together. Other regions may also choose to join. Each club is located in one of these regions. When a new club starts using SwimmPair in the future, a new region will need to be added and potential clubs created and attached to this region.

## Pairing

Pairing is simple list of pairs (**position** x **referee**)  $\rightarrow$  **cup**.

## Position

Predefined list of tasks necessary to be done at each cup. This list is probably never going to change since there is a fixed set of roles. Referees are going to be assigned to these positions for each cup.

## Schema of entities and their connections

Majority of focus should be on **referee**, **club manager** and **cup** in presented schema(Figure 1.2). Referees belong to clubs which belong to regions. These two entities **referee** and **cup** along with **position** will then be brought together as **pairing** which contains referees that are available for specific cups and will be performing work at a specified position. Referees must be available in specific time but **pairing** is where each record can be assigned a position from prescribed **positions**.

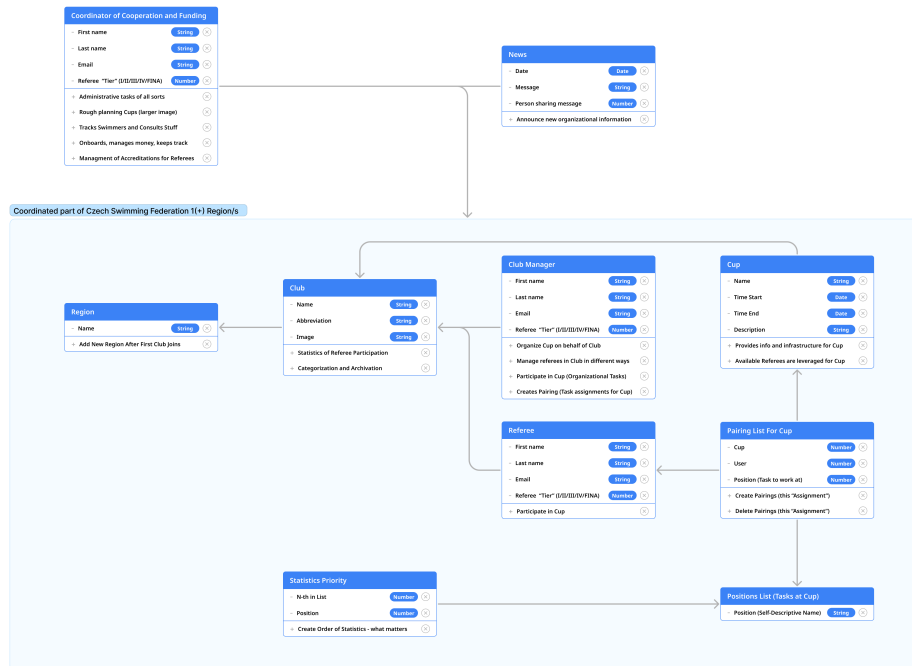


Figure 1.2: UML Class Diagram outlaying administrative structure.

## 1.5 Quality/Usability Requirements

Several good practices have to be implemented to make SwimmPair easy to use. Although some of these practices are well-known and others are situation-specific, they all share a common goal: to improve the usability of the application.

### Smooth frontend browsing

To make SwimmPair user-friendly, the frontend should be designed to be easy to use. This includes reducing page reloads, which can be achieved through asynchronous JavaScript calls to obtain partial data. The obtained data can then be used to modify the DOM using the appropriate functions.

## Multiple device types

It is certain that there are users who want to browse our system from a PC, tablet, or smartphone, so responsive design is a necessity. CSS3 supports media queries<sup>5</sup>, which we will use to create device-specific styling.

## Assigning referees to positions via. drag'n'drop

Assigning referees to positions for cups should be implemented via drag'n'drop. Dragging a referee, moving referee over the region specified for the positions and releasing mouse button. Double clicking this person is a good way of removing it.

## Printouts of pairing

Upcoming cup can be directly printed<sup>6</sup> from website and hanged as data printout.

## Appropriate design

Red, blue, and gray are common colors found at swimming pools, and they will be used in our system's design. Our UI elements should have a fresh, lightweight look that doesn't feel heavy or overwhelming to users. Specifically, we'll use these colors to create an interface that's easy to navigate and visually appealing. For example, we might use blue to highlight important information, or red to indicate errors or warnings. By using these colors consistently throughout the system, we can create a cohesive and user-friendly experience for our users.

## 1.6 Scalability/Usability Requirements

Application is initially going to be used for 2 regions and approximately 100 referees. Maximum saturation would mean that system is used in whole Czech Republic. Maximum traffic is then 5-6x larger load than the current one.

### Potentially looming issues:

- **performance issues** - shouldn't be problem using LAMP stack,
- **larger traffic** - can be solved via Kubernetes autoscaling <sup>7</sup>,
- **simulaneous application edits** - can be solved by locking and comparing hashes of states before comitting changes to database,
- **sessions consistency** - can be solved (even throughout cluster restart) using Redis<sup>8</sup> for (persistent) session handling.

These issues can be easily tackled if they are kept in mind during the development.

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<sup>5</sup>[https://developer.mozilla.org/en-US/docs/Web/CSS/Media\\_Queries](https://developer.mozilla.org/en-US/docs/Web/CSS/Media_Queries)

<sup>6</sup>[https://developer.mozilla.org/en-US/docs/Web/CSS/Media\\_Queries/Using\\_media\\_queries#targeting\\_media\\_types](https://developer.mozilla.org/en-US/docs/Web/CSS/Media_Queries/Using_media_queries#targeting_media_types)

<sup>7</sup><https://kubernetes.io/docs/tasks/run-application/horizontal-pod-autoscale/>

<sup>8</sup><https://redis.io>

## 2. System design

This chapter will familiarize reader with architecture of our application. There are two logical parts, **public web** and **private administration**. Private administration is hidden behind **login/password**.

When designing such system, object oriented approach and grouping of similar functions together is a must. There are objects that have to be moved around the web application described in previous chapter. These objects are **Post**, **User**, **Club**, **Cup**, **Position** and **Region**. Thus we came up with a concept of managers. Each page of SwimmPair is composed of same/unified header, menu, footer. The content part is filled with page's specific results of manager call used to construct data UI page layout. These managers are included and used in all pages via **start file**.

### 2.1 Technologies

Following technologies and tools are used for SwimmPair application:

- **HTML** is HyperText Markup Language <sup>1</sup> - application pages are templated in HTML by PHP,
- **CSS** is Cascading Style Sheets <sup>2</sup>,
- **PHP** is a general-purpose scripting language geared toward web development <sup>3</sup> - object model and backend services are provided by it,
- **JavaScript** is a general-purpose scripting language that conforms to the ECMAScript specification <sup>4</sup>,
- **MySQL** is an open-source relational database management system <sup>5</sup>,
- **Git** is a distributed version control system: tracking changes in any set of files - this project is versioned and kept in public GitHub repository <sup>6</sup>,
- **Docker** is a set of platform as a service products that use OS-level virtualization to deliver software in packages called containers <sup>7</sup> - used for deployment of our application,
- **GitHub Actions** is a platform for automating workflows in GitHub repositories - our application uses GitHub Actions to automate testing. Specifically, we use the PHP Action to run our backend tests using PHPUnit, along with a Docker image of our database for integration testing. We then use GitHub's reporting features to view the results of our tests and ensure that our code is functioning as expected,

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<sup>1</sup>[WHATWG, 26 December 2022]

<sup>2</sup>[W3C, 31 December 2022]

<sup>3</sup>[The PHP Group, 28 November 2019]

<sup>4</sup>[INTERNATIONAL, June 2022]

<sup>5</sup>[Oracle, 2023]

<sup>6</sup><https://github.com/KlosStepan/SwimmPair-Www>

<sup>7</sup>[Inc, 2023]



- **Kubernetes** is an open-source container orchestration system for automating software deployment, scaling, and management <sup>8</sup> - used for production deployment of our application into cluster,
- **Redis** is an in-memory data store often used for caching, messaging, and session persistence. Our application uses Redis to store session data and share it between running container instances, allowing traffic to be efficiently redirected and load-balanced.

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<sup>8</sup>[The Kubernetes Authors, 2023]

## 2.2 Architecture overview

Visitor comes to **app page**, where **managers** are included. From page there are API calls on Managers that retrieve and store data as follows.

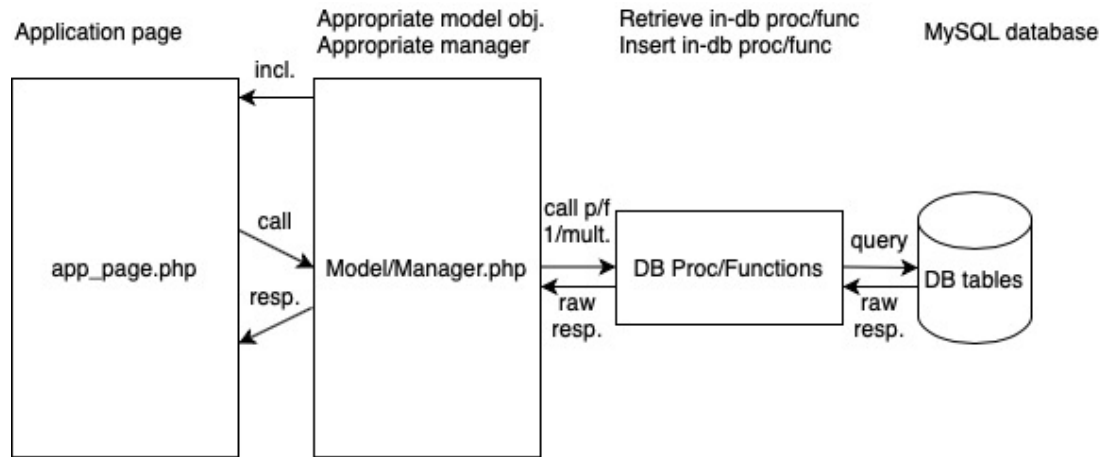


Figure 2.1: From page to manager, database, function, database and back.

## 2.3 Model Managers

Managers are written to provide API functionality for system administration. These managers are populating pages or taking new input from them and administer process of storing them. Each object has a manager handling it and accomodates database loads and stores controlled by transactions.

- Cup / CupsManager
- User / UsersManager
- Club / ClubsManager
- Page / PagesManager
- Post / PostsManager
- Position / PositionsManager
- Region / RegionsManager

Managers are implemented to extract and store data of class by which they are named after.

## 2.4 User Interface mockups

In this chapter, we present UI mockups for both public and private areas of our application. These mockups serve as initial visualizations for the real UI, but should not be considered exact guidelines. Instead, they provide a starting point for readers and stakeholders to understand the overall direction of the UI design.

### Public website mockups

This part is concerned about displaying view-only data for public access.

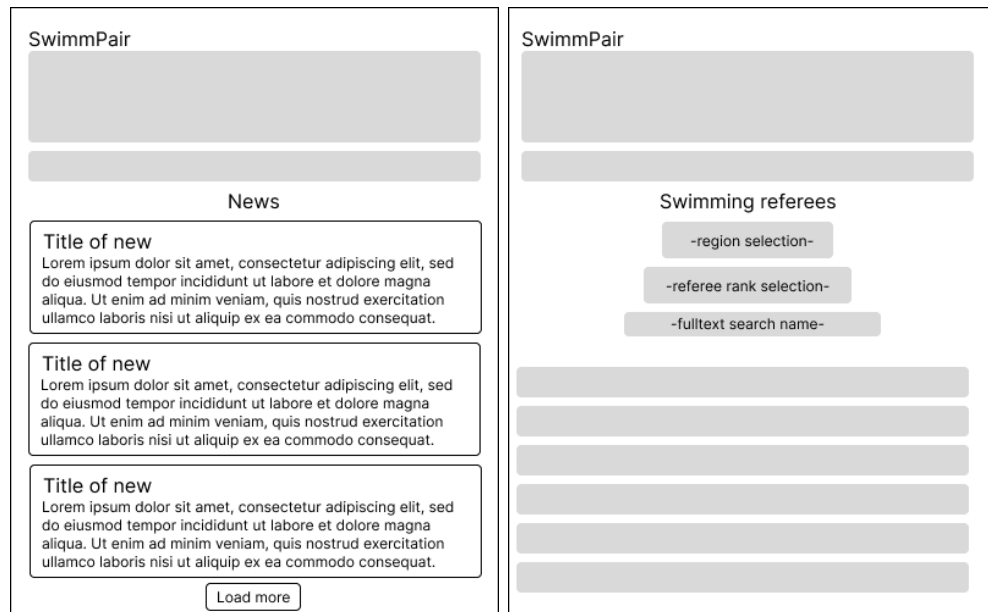


Figure 2.2: Public pages - homepage (S5) and listing of users (R3/S4).

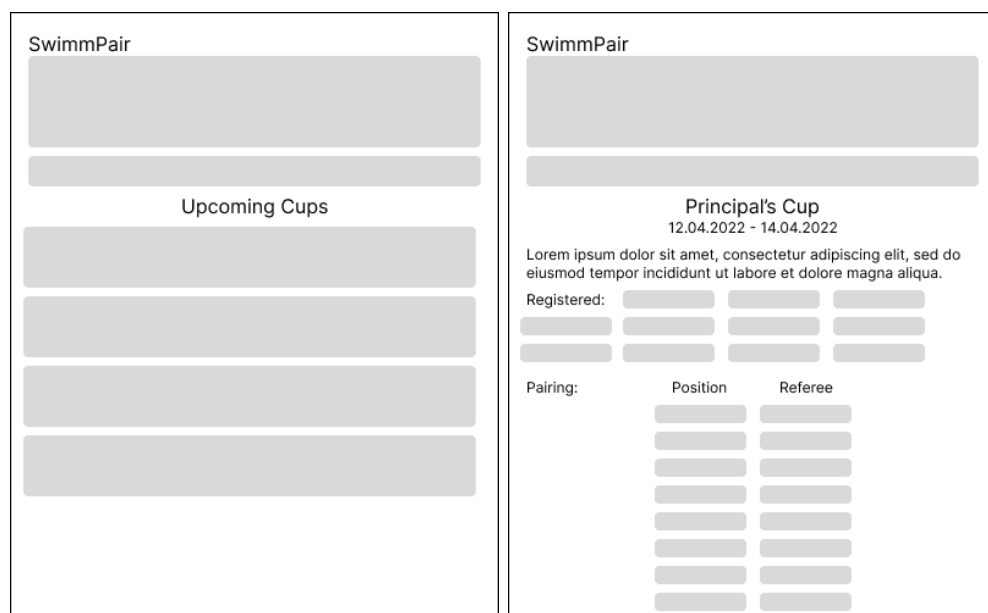


Figure 2.3: Public pages - cups listing and cup preview (C3).

## Administration mockups

After logging in, user can see administrative menu. Based on rights (2/1/0) one gets layout of appropriate sections. There is list things related to everything from administrative perspective. We will show several mockups of how functional requirements for administration can look like once programmed and designed.

The left mockup shows a dashboard layout. At the top, there's a header with 'SP' on the left, 'Welcome' in the center, and 'Settings' on the right. Below the header, there's a sidebar menu with sections: 'ADMINISTRATIVE TASKS' (containing a list of items), 'MY CLUB' (containing a list of items), and 'MY REFEREE PARTICIPATION' (containing a list of items). The right mockup shows an 'Edit Page' form. It has a back arrow on the top left, a title field, a content field, and an 'Update' button at the bottom.

Figure 2.4: Administration menu gets assembled on rights, page edit (S6).

The left mockup shows the 'Add Cup' form. It has a back arrow on the top left, a title 'Add Cup', and a 'Cup name' field. Below that, there are fields for 'Date start', 'Date end', and 'Organizing club' (with a placeholder '-name of user's club here-'). There is also a 'Description of cup' field and an 'Add Cup' button at the bottom. The right mockup shows the 'drag'n'drop pairing' interface. It has a back arrow on the top left, a title 'Cup name' with a date '08/08/2020', and a 'PREV' button on the top right. Below the title, there's a section 'Available referees' with a list of referees. There are two fields: 'Main referee' and 'Starter', both with dropdown menus. Arrows indicate the drag'n'drop pairing from the 'Available referees' list to the 'Main referee' and 'Starter' fields. There is also an ellipsis '...' below the 'Starter' field.

Figure 2.5: Add Cup (C1) and drag'n'drop pairing (C2).

## 2.5 Database design

While designing such system, well defined database schema modelled from functional requirements and entities is a necessity. Previously outlined real world (Figure 1.2) has to be rigorously converted to database schema. We will show mappings and merges that had to be made in order to achieve that.

### People entities merge

We've merged three entities (Coordinator, Club Manager, and Referee) that model people into a single entity called User, which includes additional parameters such as access rights and club affiliation.

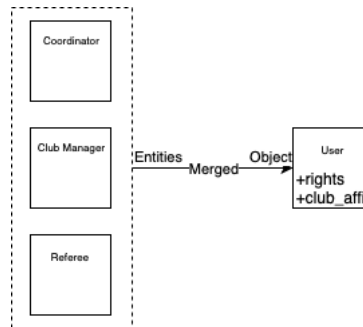


Figure 2.6: These 3 people entities got merged into the single object.

### Pairing entities to objects

Majority of logic is modelled as entities. Availability must precede Pairing.

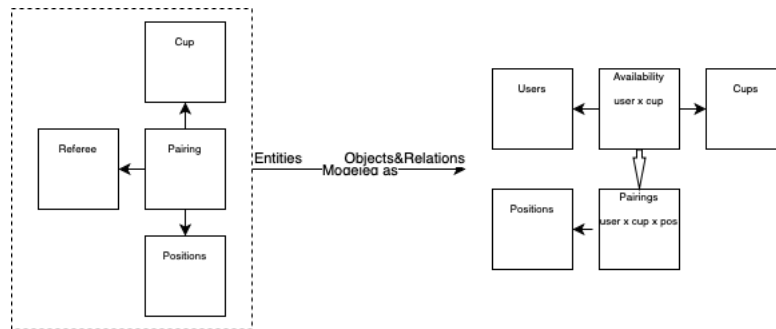


Figure 2.7: Entities modeled as 3 objects and 2 relational tables.

### Remaining entities

Mapping of remaining entities is self-evident.

## Full database schema used for out application

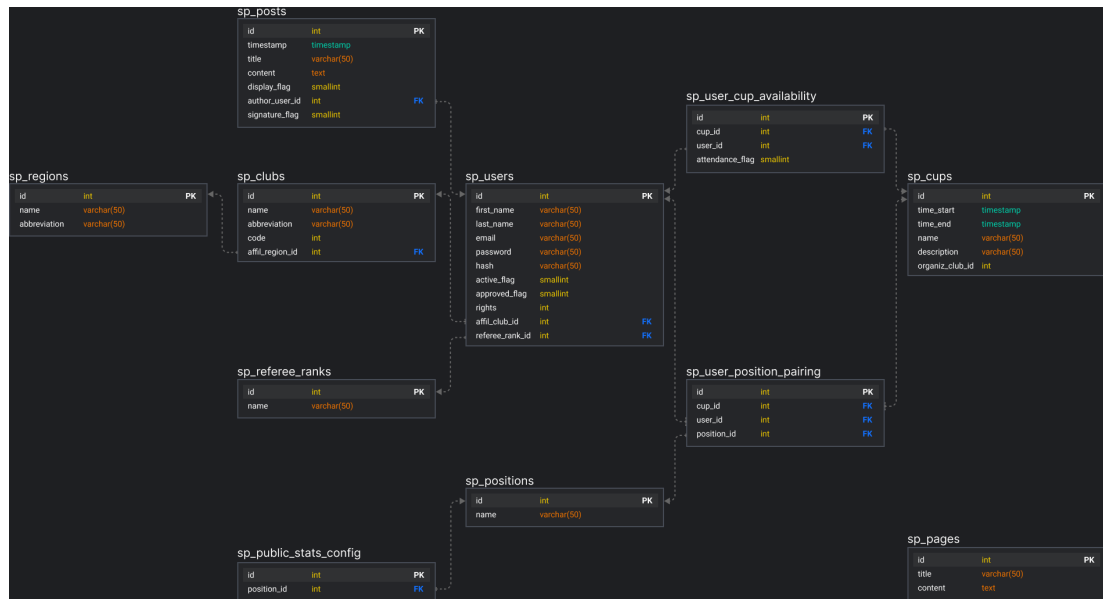


Figure 2.8: Full database schema for the SwimmPair application.

## 2.6 Functional requirements mapping to API

We will show how specific **functional requirements** administrative tasks are realized via **model api functions**<sup>9</sup>.

Table has following structure: **Task / Role / Function(s)**.

Add Post	system admin	InsertNewPost
Edit Post	system admin	UpdatePost
Approve New Users	system admin	SetApprovedForUser
Create Pairing For Cup	system admin	DeleteOldPairing InsertNewPairing
Add User	system admin	RegisterUser
Edit User	system admin	SetLoginEmailForUser SetRefereeRankForUser SetPasswordForUser
Add Club	system admin	InsertNewClub
Edit Club	system admin	UpdateClub
Add Region	system admin	InsertNewRegion
Edit Region	system admin	UpdateRegion
Configure Stats	system admin	DeleteOldStatsPositions InsertNewStatPosition
Edit Contacts	system admin	UpdatePage
Add Cup	club manager	InsertNewCup
Sign People From My Club Available For Cup	club manager	DeleteOldAvailability InsertNewAvailability
Sign Myself As Available For Cup	referee	SetAvailabilityRegister SetAvailabilityCantGo SetAvailabilityCanGo

---

<sup>9</sup>[http://docu.swimmpair.cz/functions\\_func.html](http://docu.swimmpair.cz/functions_func.html)

## 3. Implementation Documentation

Detailed description of **database** and **backend components** and **functions**.

### 3.1 Database

Full database schema of the application was already shown in previous chapter (Figure 2.8). This chapter will introduce reader to detailed description of tables and their relations.

Each database table is accompanied with example table preview, where:

- abbreviated column name: (a),
- contracted/omitted info: ...,

followed by full listing of attributes - datatypes, keys, etc.

#### 3.1.1 Object tables

These are the tables in database modeling the object to satisfy the primary motivation defined as the (Figure 1.2). These rows are then being converted to **Object** or **Array<Object>** (Club, Cup, Page, PairPositionUser, Position, Post, RefereeRank, Region, StatPositionCnt, StatUserCnt, User) and returned to application page by appropriate Manager.

##### **sp\_posts**

**Post** is a static snippet of news for homepage of web application.

Table preview

id	timestamp	title	content	d_flag(a)	auth_id(a)	sign(a)
1	2023-01-...	Running...	SwimmPair...	1	21	0
2	2023-03-...	Updates	This web...	1	21	0
...	...	...	...	...	...	...

Columns description

1. **id|PK**, int(11) *Auto Increment*
2. **timestamp**, datetime *NULL [CURRENT\_TIMESTAMP]*
3. **title**, text
4. **content**, text
5. **display\_flag**, tinyint(1)
6. **author\_user\_id|FK**, int(11) *NULL*
7. **signature\_flag**, tinyint(1)



### sp\_users

User is referee in the system. User is affiliated to Club has one of UserRights and one of tier from RefereeRank. His statistics are presented via StatUserCnt in public sites via PositionsManager.

Table preview

id	first_name	last_name	email	password	hash	...
1	Lukáš	Kousal	lukas@swim.cz	-PASS-	-HASH-	...
...	...	...	...	...	...	...
N	...	...	...	...	...	...

Columns description

1. **id**|**PK**, int(11) *Auto Increment*
2. **first\_name**, varchar(50)
3. **last\_name**, varchar(50)
4. **email**, varchar(100) //unique identifier
5. **password**, varchar(100)
6. **hash**, varchar(32)
7. **active\_flag**, tinyint(1) [0]
8. **approved\_flag**, tinyint(1) [0]
9. **rights**, tinyint(1)
10. **referee\_rank\_id**|**FK**, int(11)
11. **affiliation\_club\_id**|**FK**, int(11)

### sp\_clubs

Club is an administrative unit of swimming club grouping bunch of users. One User is ClubManager/1 from UserRights, the rest is Referee/0. It can organize.

Table preview

id	name	abbrev(a)	club_id	img
1	Klub plaveckých sportů Vyškov	KPSVy	614	vyskov.jpg
...	...	...	...	...
14	TJ Rožnov pod Radhoštěm	TJRo	0	roznov.jpg

Columns description

1. **id**|**PK**, int(11) *Auto Increment*
2. **name**, varchar(80)
3. **abbreviation**, text
4. **code** int(11) *NULL*
5. **img**, text *NULL*
6. **affiliation\_region\_id**|**FK**, int(11)

### sp\_cups

Cups are stored in this table.

Table preview

id	t_st(a)	t_e(a)	name	desc(a)	org_c_id(a)
1	2023-...	2023-...	GJW Cup I.	Cup organized by ...	2
...	...	...	...	...	...

Columns description

1. **id**|**PK**, int(11) *Auto Increment*
2. **time\_start**, date
3. **time\_end**, date
4. **name**, text
5. **description**, text
6. **organizer\_club\_id**|**FK**, int(11)

### sp\_positions

Position is object representing task for Cup that has to be performed by User. It has internal id based on which it is wired through the system internally.

Table preview

id	name
1	Vrchní rozhodčí
...	...
19	Ostatní

Columns description

1. **id**|**PK**, int(11), *Auto Increment*
2. **name**, varchar(45)

## 3.1.2 Relation tables

Relation tables hold the most important information stored in the SwimmPair system - the **pairings** and **data for underlying statistics**. Both availability for cups and pairings to positions are represented here.

### sp\_user\_cup\_availability

This table stores relationships between referees/users and cups called availability. Referees are signed up by their team manager or themselves as available for the cup. In case of sudden inability to participate, the `attendance_flag` is switched to 0 in case the user is already assigned to some position. In that case the administrator is going to see the user in red box.

Table preview

id	cup_id	user_id	attendance_flag
1	3	21	1
2	3	1	1
7	3	19	0
...	...	...	...

#### Columns description

1. **id**|**PK**, int(11) *Auto Increment*
2. **cup\_id**|**FK**, int(11)
3. **user\_id**|**FK**, int(11)
4. **attendance\_flag**, tinyint(1) [1]

### **sp\_user\_position\_pairing**

This table stores pairing information about available referees/users on positions for each cup. This is the most time saving utility of the SwimmPair.

#### Table preview

id	cup_id	position_id	user_id
46	5	5	21
484	3	1	21
485	3	1	22
486	3	2	7
487	3	3	15
487	3	5	12
487	3	7	14
...	...	...	...

#### Columns description

1. **id**|**PK**, bigint(20) *Auto Increment*
2. **cup\_id**|**FK**, int(11)
3. **position\_id**|**FK**, int(11)
4. **user\_id**|**FK**, int(11)

### **3.1.3 Content adjustment tables**

#### **sp\_public\_stats\_config**

Configuration table of which positions in what order should be displayed in statistics on frontend. For frontend then LEFT-JOIN **position\_id** from table **sp\_positions** ON **id** and display **sp\_positions.name**.

#### Table preview

id	position_id
148	1
149	8
150	2
151	4
152	6

#### Columns description

1. **id**|**PK**, int(11) *Auto Increment*
2. **position\_id**|**FK**, int(11)

#### **sp\_pages**

**Page** is static website page with information in web application. It has some title and content.

#### Table preview

id	title	content
1	Kontakty	<h1>Title</h1><p>Contact information +420...</p>

#### Columns description

1. **id**|, int(11) *Auto Increment*
2. **title**, text
3. **content**, text

## 3.2 Managers documentation

These five managers work with objects and provide views and functions (i.e. joining more tables in various ways to achieve all functionality). We're providing an overview of which API functions are calling which internal functions (plain, in cycle) and what are desired return values.

**Documentation of model - classes and public functions is available <sup>1</sup>.**

### 3.2.1 PostsManager.php

PostsManager has API functions to handle Post object/s and delivers it through web application.

- Post | null  $\leftarrow$  **GetPostById**(\$id)
  - $\searrow$  `_CreatePostOrNullFromStatement($stmt)`
  - $\searrow$  `_CreatePostFromRow($row)`
- Post[] | null  $\leftarrow$  **FindLastNPosts**(\$N)
  - $\searrow$  `_CreatePostsFromStatement($stmt)`
  - $\hookrightarrow$  `_CreatePostFromRow($row)`
- true | false  $\leftarrow$  **InsertNewPost**(\$title, \$content, \$d\_flag, \$auth\_id, \$sign)
- Post[] | false  $\leftarrow$  **FindAllPostsOrderedByIdDesc**()
  - $\searrow$  `_CreatePostsFromStatement($stmt)`
  - $\hookrightarrow$  `_CreatePostFromRow($row)`
- true | false  $\leftarrow$  **UpdatePost**(\$id, \$title, \$content, \$d\_flag, \$sign)

### 3.2.2 UsersManager.php

UsersManager has API functions to handle User object/s and delivers it through web application.

- User | null  $\leftarrow$  **GetUserById**(\$id)
  - $\searrow$  `_CreateUserOrNullFromStatement($stmt)`
  - $\searrow$  `_CreateUserFromRow($row)`
- User[] | null  $\leftarrow$  **FindAllActiveUsersOrderByLastNameAsc**()
  - $\searrow$  `_CreateUsersFromStatement($stmt)`
  - $\hookrightarrow$  `_CreateUserFromRow($row)`
- User[] | null  $\leftarrow$  **FindAllInactiveUsersOrderByLastNameAsc**()
  - $\searrow$  `_CreateUsersFromStatement($stmt)`
  - $\hookrightarrow$  `_CreateUserFromRow($row)`
- User[] | null  $\leftarrow$  **FindAllRegisteredTeamMembersForTheCup**(\$cupId, \$teamId)
  - $\searrow$  `_CreateUsersFromStatement($stmt)`
  - $\hookrightarrow$  `_CreateUserFromRow($row)`
- User[] | null  $\leftarrow$  **FindAllTeamMembers**(\$teamId)
  - $\searrow$  `_CreateUsersFromStatement($stmt)`
  - $\hookrightarrow$  `_CreateUserFromRow($row)`

---

<sup>1</sup><http://docu.swimmpair.cz>

- $\underline{\text{User}}[] \mid \text{null} \leftarrow \mathbf{FindAllRegisteredUsersForTheCup}(\$cupId)$   
 $\searrow \_CreateUsersFromStatement(\$stmt)$   
 $\hookrightarrow \_CreateUserFromRow(\$row)$
- $\underline{\text{User}}[] \mid \text{null} \leftarrow \mathbf{FindPairedUsersOnCupForPosition}(\$cupId, \$posId)$   
 $\searrow \_CreateUsersFromStatement(\$stmt)$   
 $\hookrightarrow \_CreateUserFromRow(\$row)$
- $\underline{\text{string}} \mid \text{null} \leftarrow \mathbf{GetClubAbbreviationByAffiliationId}(\$id)$   
 $\searrow \_GetSingleResultFromStatement(\$stmt)$
- $\underline{\text{string}} \mid \text{null} \leftarrow \mathbf{GetUserFullNameById}(\$id)$   
 $\searrow \_GetSingleResultFromTwoColsStatement(\$stmt)$
- $\underline{\text{true}} \mid \underline{\text{false}} \leftarrow \mathbf{IsEmailPresentAlready}(\$email)$
- $\underline{\text{true}} \mid \underline{\text{false}} \leftarrow \mathbf{RegisterUserFromAdmin}(\$first\_name, \$last\_name, \$email, \$password, \$rights, \$klubaffil)$
- $\underline{\text{true}} \mid \underline{\text{false}} \leftarrow \mathbf{EmailNewPersonRegistered}(\$email, \$password)$
- $\underline{\text{true}} \mid \underline{\text{false}} \leftarrow \mathbf{SetApprovedForUser}(\$userId)$

### 3.2.3 ClubsManager.php

ClubsManager has API functions to handle Club object/s and delivers it through web application.

- $\underline{\text{Club}} \mid \text{null} \leftarrow \mathbf{GetClubById}(\$id)$   
 $\searrow \_CreateClubFromStatement(\$stmt)$   
 $\searrow \_CreateClubFromRow(\$row)$
- $\underline{\text{Club}}[] \mid \text{null} \leftarrow \mathbf{FindAllClubs}()$   
 $\searrow \_CreateClubsFromStatement(\$stmt)$   
 $\hookrightarrow \_CreateClubFromRow(\$row)$

### 3.2.4 CupsManager.php

CupsManager has API functions to handle Cup object/s and delivers it through web application.

- $\underline{\text{Cup}}[] \mid \text{null} \leftarrow \mathbf{FindAllUpcomingCupsEarliestFirst}()$   
 $\searrow \_CreateCupsFromStatement(\$stmt)$   
 $\hookrightarrow \_CreateCupFromRow(\$row)$
- $\underline{\text{Cup}}[] \mid \text{null} \leftarrow \mathbf{FindAllPastCupsMostRecentFirst}()$   
 $\searrow \_CreateCupsFromStatement(\$stmt)$   
 $\hookrightarrow \_CreateCupFromRow(\$row)$
- $\underline{\text{Cup}} \mid \text{null} \leftarrow \mathbf{GetCupById}(\$id)$   
 $\searrow \_CreateCupOrNullFromStatement(\$stmt)$   
 $\searrow \_CreateCupFromRow(\$row)$
- $\underline{\text{Pair}}[] \mid \text{null} \leftarrow \mathbf{FindPairingsForThisCup}(\$id)$   
 $\searrow \_CreatePairsFromStatement(\$stmt)$   
 $\hookrightarrow \_CreatePairFromRow(\$row)$

- true | false  $\leftarrow$  **InsertNewCup**(\$name, \$t\_st, \$t\_end, \$club, \$content)
- true | false  $\leftarrow$  **IsUserAvailableForTheCup**(\$userId, \$cupId)

Called together in XMLHttpRequest/**update\_availability.php** in transaction.

- true | false  $\leftarrow$  **DeleteOldAvailability**(\$cupId)
- true | false  $\leftarrow$  **InsertNewAvailability**(\$cupId, \$userId, 1)

Called together in XMLHttpRequest/**update\_pairing.php** in transaction.

- hash | null  $\leftarrow$  **GetPairingHashForThisCup**(\$cupId)  
 $\searrow$  \_GetSingleResultFromStatement(\$stmt)
- true | false  $\leftarrow$  **DeleteOldPairing**(\$cupId)
- true | false  $\leftarrow$  **InsertNewPairing**(\$cupId, \$posId, \$userId)

### 3.2.5 PositionsManager.php

PositionsManager has API functions to handle Position object/s and delivers it through web application.

- Position[] | null  $\leftarrow$  **FindAllPositions**()  
 $\searrow$  \_CreatePositionsFromStatement(\$stmt)  
 $\hookrightarrow$  \_CreatePositionFromRow(\$row)
- string | null  $\leftarrow$  **GetPositionNameById**(\$id)  
 $\searrow$  \_GetSingleResultFromStatement(\$stmt)

### 3.3 Start file

Start file is included the in beginning of each page. It serves for **connection to database**, **sanitization of input**, **definition of error handling** and most importantly **includes objects and managers** and subsequently **instantiates all managers** by passing reference to live database connection `$mysqli` - their only constructor argument.

```
/*Database credentials from environment*/
$host = getenv("DATABASE_HOST");
$user = getenv("DATABASE_USER");
$pass = getenv("DATABASE_PASS");
$db = getenv("DATABASE_NAME");
/*Database connection and charset set*/
$mysqli = new mysqli($host, $user, $pass, $db) or die($mysqli->error
);
$mysqli->set_charset('utf8');
/* Sanitization function */
function h($string)
{
    return htmlspecialchars($string);
}
/* Exception handling*/
error_reporting(E_ALL);
ini_set("display_errors", 1);
set_exception_handler(function () {
    echo "<h3_style=\"color:red;\">INVALID REQUEST</h3>";
    exit();
});
/* Objects and Managers inclusion*/
require __DIR__ . '/model/Sanitizer.php';
require __DIR__ . '/model/Auth.php';
require __DIR__ . '/model/Post.php';
require __DIR__ . '/model/PostsManager.php';
require __DIR__ . '/model/Page.php';
require __DIR__ . '/model/PagesManager.php';
require __DIR__ . '/model/StatUserCnt.php';
require __DIR__ . '/model/StatPositionCnt.php';
require __DIR__ . '/model/RefereeRank.php';
require __DIR__ . '/model/Region.php';
require __DIR__ . '/model/RegionsManager.php';
require __DIR__ . '/model/User.php';
require __DIR__ . '/model/UsersManager.php';
require __DIR__ . '/model/Cup.php';
require __DIR__ . '/model/PairPositionUser.php';
require __DIR__ . '/model/CupsManager.php';
require __DIR__ . '/model/Position.php';
require __DIR__ . '/model/PositionsManager.php';
require __DIR__ . '/model/Club.php';
require __DIR__ . '/model/ClubsManager.php';
/* Construction of Managers w/ reference to $mysqli */
$postsManager = new PostsManager($mysqli);
$pagesManager = new PagesManager($mysqli);
$usersManager = new UsersManager($mysqli);
$clubsManager = new ClubsManager($mysqli);
$cupsManager = new CupsManager($mysqli);
$positionsManager = new PositionsManager($mysqli);
$regionsManager = new RegionsManager($mysqli);
```

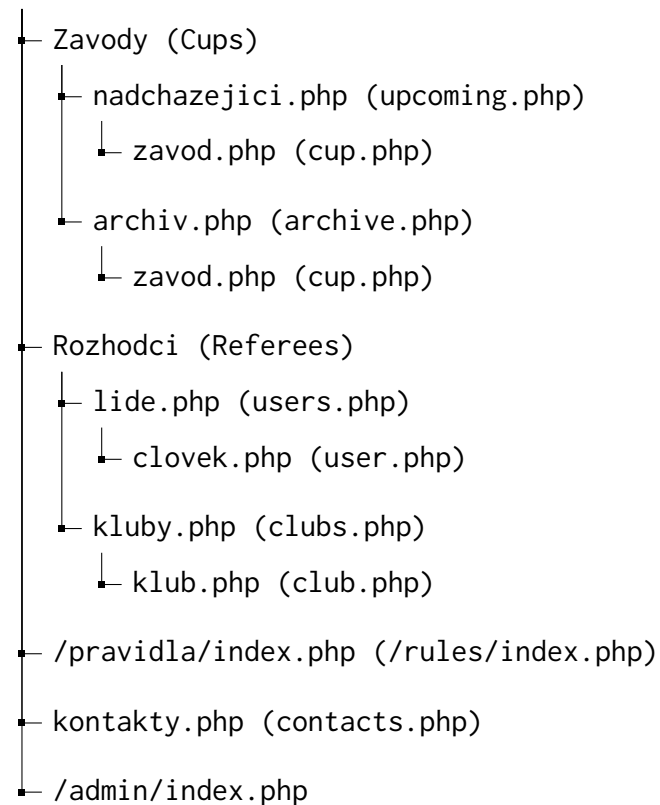


## 3.4 Application structure - files defined

### User part of the system

The system is running on Czech URLs for convinience reasons of browsing. English equivalentents of route pages are attached in brackets to demonstrate what the pages do for non-czech speaker. There is no client side routing with traditional LAMP stack.

`www.SwimmPair.cz/index.php`



## Admin part of the system

The administration has following structure. After going to /admin/index.php user gets logs in and goes to /administration/profile.php. Regarding user's rights (that are passed around along with other information in **SESSION**, retrievable like **\$SESSION['rights']**) one has following structure (**Administration, My Club, Me**). Each user has profile settings for resetting password and other stuff.

[www.SwimmPair.cz/administration/profile.php](http://www.SwimmPair.cz/administration/profile.php)



## 3.5 Templating of web and administration

Each page layout of public website has common characteristics such as header, menu and footer. These sections are unified and included everywhere, therefore they are included everywhere. They are:

- **HEADER**,
- **MENU**,
- Generated from result obtained by one or more manager calls. this section might be further updated via **XMLHttpRequest calls & DOM modifications** of newly delivered data,
- **FOOTER**.

Homepage of administration panel /admin/profile.php after login gets assembled with regards to the rights of logged user. Ordering is following: Admin (2) > Club manager (1) > Swimming referee (0) and each user gets snippet of his and lower role snippets:

- **SUPERUSER** menu snippet - **2**,
- **CLUB MANAGER** menu snippet - **1**,
- **SWIMMING REFEREE** menu snippet - **0**.

Access to different pages is then discriminated based on rights code on each page.

### Rights check on each page in administration

```
<?php
require __DIR__ . '/../start.php';
session_start();
Auth::requireRole(UserRights::SuperUser);
...
?>
...
```

### Static requireRole function on Auth class for access permission

```
class Auth
{
    public static function requireRole($role)
    {
        if (!isset($_SESSION['rights']))
        {
            header('Location: ../prihlaseni.php');
            exit();
        }
        //Rights sharply lower than user has, throw RuntimeException
        if ($_SESSION['rights'] < $role)
        {
            echo '<h1>Not enough rights</h1>';
            echo $_SESSION['rights'];
            echo $role;
            throw new RuntimeException();
        }
    }
}
```

## 3.6 JavaScript functionality documentation

Frontend functionality is implemented via Vanilla JavaScript. Majority of interactive stuff takes place on **public part** of the application. This section will give reader a glimpse into how things work on the frontend.

### Functions in js/SwimmPairFrontendJSLib.js

Functions in this library were created to support Ajax calls and DOM operations for **public part** of our application. Functions have self-descriptive names, function parameter **this** means reference to the caller DOM element.

Functions are general & contain **XMLHttpRequest** and **DOM modification**:

- **GetPostAppendPost(PushLastId())**
  - ↘ ConstructNextPost(id, timestamp, title, content, author, signed)
- **ProcessClubForTheSeason(clubId, this)**
  - ↘ CommunicateClubStatsXHRAndUpdateTable(clubId, year)
  - ↘ UpdateClubStatsTable(returnedJSON)
- **ProcessPersonForTheSeason(userId, this)**
  - ↘ CommunicateUserStatsXHRAndUpdateTable(userId, year)
  - ↘ UpdateUserStatsTable(cnt, arr\_str)

### Backend endpoints for XMLHttpRequests

- get\_post\_following.php, **GET args:** id
- get\_person\_statistics\_for\_the\_season.php, **GET args:** user\_id, year
- get\_club\_statistics\_for\_the\_season.php, **GET args:** club\_id, year

#### 3.6.1 Previous post - retrieve older post

This button on the main page serves as a tool for loading next post. It has **onclick="GetPostAppendPost(PushLastId())"**. Both are JavaScript functions, **PushLastId()** detects id **<article class="post" id="X"...** of last article **class="post"** from DOM by **querySelector** and returns it. This value is then used as an argument of call **GetPostAppendPost(id)**. This function requests article by GET request **XMLHttpRequest/get\_following\_post.php?id=X**. The result can be:

- **null** - button is deleted since there are no other articles to pull from DB,
- **post** - next article is constructed and appended from response.

#### 3.6.2 User statistics - year change

All individual referees have seasons years picker when opened. Default season is the current season. Clicking different season visibly changes selected year and obtains appropriate statistics and updates the stats table. Clicking **<span onclick="ProcessPersonForTheSeason(userId, this)"...** calls

inside `CommunicateStatsXhrAndPopulateStats(userId, year)` gets data from `XMLHttpRequest/call_get_person_statistics_for_the_season.php?id=userId&year=YYYY` and updates table. Also via this reference in call the button is marked as selected.

### 3.6.3 Club statistics - year change

Club statistics are updated by clicking appropriate year that gets switched. Year onclick calls `ProcessClubForTheSeason(clubId, this)` which gets statistics by calling `CommunicateClubStatsXhrAndUpdateTable(clubId, year)` by calling `XMLHttpRequest/get_club_statistics_for_the_season.php?id=clubId&year=Year` and subsequently calling function modifying DOM `UpdateClubStatsTable(returnedGetJSON)` which literally updates stats.

### 3.6.4 Filtering referees

Refiltering of referees is triggered by one of these (Figure 3.1) functions on events:

- **region changed** - onclick="RegionPickerChanged(this)",
- **ref. rank changed** - onclick="RefereeRankPickerChanged(this)",
- **searchbar changed** - onkeyup="SearchBarChanged()".

Registrovaní rozhodčí

VŠE OLK ZLK

VŠE I. II. III. FINA

Hledat...

Adamec      Petr      I.      Olomoucký kraj

Figure 3.1: Filtering of referees for statistics (requirements R3/S4).

`FilterQueriedReferees("kraje", "tridy", "inputTrida", "nopplfound")` is called every time one of 3 controls is changed.

We then loop all users **visible&hidden** and check if this one's **Region** - `IsOptionPermissible(raid, args[])` (region id), **Rank** - `IsOptionPermissible(rrid, args[])` (referee rank id) and then if one's **Name** - `IsNamePermissible(args[])` starts with queried piece of string from the search bar. We then set one's element style to `style=""` and continue looping. If we fail one of these three conditions we know that referee does not satisfy search conditions and set referee's element's style to `style="display:none"` - to make referee not visible in the listing.

```

...
//Querying
if (IsOptionPermissible(raid , krajeIDs)) {
    if (IsOptionPermissible(rrid , tridyIDs)) {
        if (IsNamePermissible(jmeno, first_name , last_name)) {
            articlePerson.setAttribute("style", "");
            empty = false;
            continue;
        }
    }
}
//Some Condition Fails – Not Permissible
articlePerson.setAttribute("style", "display:none;");
}

```

## 4. Testing

There are two main ways to make sure that a web application works properly and fulfills its role. On one hand there is a code performance testing, performing test on backend level with dummy data insertion and performance benchmarking. On the other hand there is testing to assure that users are able to use system and to get inspiration for future UX improvements via SUS.

### 4.1 Performance evaluation

Performance script **dummy\_data\_benchmark.php**<sup>1</sup> is located in main swimm-pair folder. It is performed on default database installation (with 2 admin users, with already existing clubs administered by application requesters, and with default referee positions).

**The script has several tasks (tests) which are performed and benchmarked.**

1. Create 98 Users (no. 3-100) - each random affiliation to existing Club (no. 1-15).
2. Create 12 Cups - each random affiliation to existing Club (no. 1-15).
3. Fetch new Users, fetch new Cups (+ fetch static Positions).
4. Create Availabilities (20 Users available per Cup).
5. Create Pairings (each Availability gets 1 random position).
6. Call stats queries (20 - randomly either Clubs or Users stats w/ random club.id or user.id).

**Docker Compose** - 2.3 GHz Core i5 (I5-8259U) RAM 16GB Storage 512GB

T/rep no.	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Test #1	7.02	7.04	6.61	7.89	6.73	6.62	6.66	7.34	7.19	6.54
Test #2	0.08	0.06	0.06	0.06	0.06	0.10	0.58	0.60	0.50	0.15
Test #3	7.02	7.05	6.61	7.90	6.74	6.63	6.66	7.35	7.20	6.55
Test #4	1.24	1.05	1.14	1.05	1.18	1.17	1.24	1.15	0.96	1.59
Test #5	8.02	7.87	7.39	8.95	7.70	7.81	7.44	8.12	7.98	7.36
Test #6	1.29	1.10	1.19	1.12	1.23	1.22	1.28	1.19	1.00	1.62
TOTAL	<u>9.31</u>	<u>8.97</u>	<u>8.59</u>	<u>10.06</u>	<u>8.93</u>	<u>9.03</u>	<u>8.72</u>	<u>9.31</u>	<u>8.98</u>	<u>8.98</u>

**Kubernetes - DOKS** Kubernetes v 1.25.4-do.0, s-1vcpu-2gb-intel

T/rep no.	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Test #1	7.08	6.87	6.79	6.85	7.20	7.10	6.77	6.85	6.81	6.79
Test #2	0.04	0.03	0.04	0.04	0.04	0.03	0.05	0.05	0.03	0.04
Test #3	7.08	6.88	6.79	6.86	7.20	7.10	6.77	6.85	6.81	6.79
Test #4	0.84	0.59	0.68	0.81	0.60	0.55	0.70	0.82	0.60	0.67
Test #5	7.72	7.40	7.55	7.56	7.69	7.60	7.35	7.56	7.33	7.40
Test #6	0.86	0.61	0.70	0.84	0.62	0.57	0.72	0.84	0.62	0.69
TOTAL	<u>8.57</u>	<u>8.01</u>	<u>8.25</u>	<u>8.40</u>	<u>8.31</u>	<u>8.17</u>	<u>8.07</u>	<u>8.39</u>	<u>7.95</u>	<u>8.09</u>

<sup>1</sup>In <https://github.com/KlosStepan/SwimmPair-Www> **dummy\_data\_benchmark.php**

## 4.2 System Usability Scale testing

We carried on testing of our application by handing SUS questionare to 20 respondents. We then evaluated the scores in order to find out how our application stands. These people are either managers or common referees <sup>2</sup>.

**Questionare is made of 10 questions scored 1-5.**

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

**We calculated<sup>3</sup> SUS feedbacks based on responses from 20 people.**

Respondent / Q. no.	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Petr A - <b>87.5</b>	5	1	3	1	5	1	3	1	5	2
Olga A - <b>72.5</b>	2	1	3	2	4	1	5	1	3	3
Marin H - <b>75</b>	3	1	4	2	5	1	3	2	3	2
Michaela H - <b>60</b>	2	3	3	4	3	2	4	2	5	2
Stepan K - <b>85</b>	5	2	4	1	3	1	3	1	5	1
Matylda K - <b>80</b>	4	1	4	2	4	1	4	2	4	2
Lukas Kour. - <b>67.5</b>	2	2	5	2	4	1	4	2	2	3
Jana K - <b>60</b>	1	2	3	2	5	2	3	2	2	2
Lukas Kous. - <b>92.5</b>	5	1	4	1	5	1	4	1	5	2
Zuzana K - <b>70</b>	3	2	5	1	3	1	3	2	3	3
Eva K - <b>80</b>	3	2	5	1	3	1	3	1	4	1
Michael P - <b>75</b>	2	1	4	3	4	1	4	1	3	1
Lenka P - <b>70</b>	3	2	5	1	3	2	3	2	3	2
Daniela S - <b>77.5</b>	3	2	5	2	3	1	4	2	4	1
Magdalena S - <b>85</b>	4	1	4	1	4	1	5	1	3	2
Jiri S - <b>62.5</b>	3	3	5	3	4	2	3	3	2	1
Hana S - <b>80</b>	2	2	4	1	5	1	4	1	4	2
Alena T - <b>90</b>	4	1	5	1	3	1	4	1	5	1
Magda Z - <b>85</b>	3	2	5	2	4	1	4	1	5	1
Vera Z - <b>75</b>	3	3	4	1	3	1	3	1	4	1

<sup>2</sup>John Brooke [1995]

<sup>3</sup> $((A1-1)+(5-A2)+(A3-1)+(5-A4)+(A5-1)+(5-A6)+(A7-1)+(5-A8)+(A9-1)+(5-A10))*2,5$



So we plotted our tes results for further investivation. We can compare results and it's distribution in boxplot or look further into specific questions.

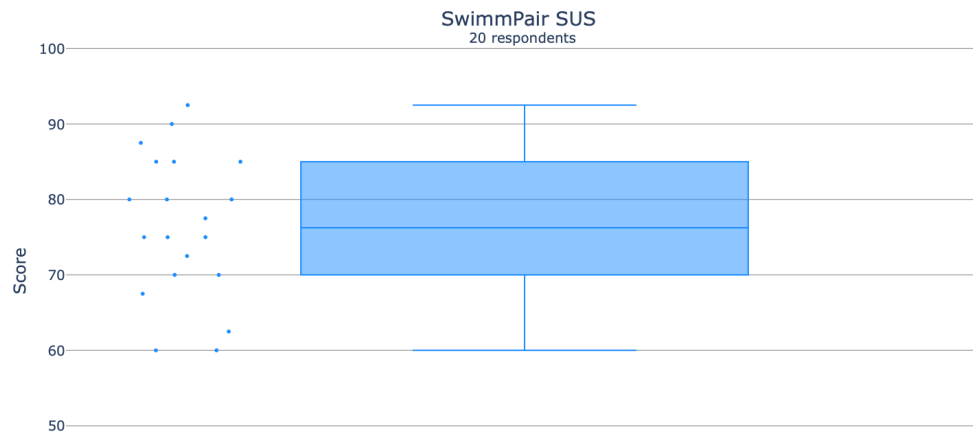


Figure 4.1: Boxplot of 20 SUS score results.

## 4.3 Unit testing

Testing serves two puposes:

- **firstly** - to ensure that functionality works as intended,
- **secondly** - not only that newly added functionaly works as intended but also that any previous functions and mechanisms were not broken either.

There is bunch of PHPUnit tests for each Manager called ManagerTest.php in folder **tests/Unit** in our project. Tests check ordinary CRUD <sup>4</sup> functionalities.

### 4.3.1 Local execution of tests

Preview the results of test during local development by attaching VS Code to the running Container <sup>5</sup> and seeing results in PHP Tools by DEVSENSE <sup>6</sup> on the left side. We can also open command line (within container environment already) `docker@6bd3d752da84:/var/www/html` and run tests simply by using **phpunit** command.

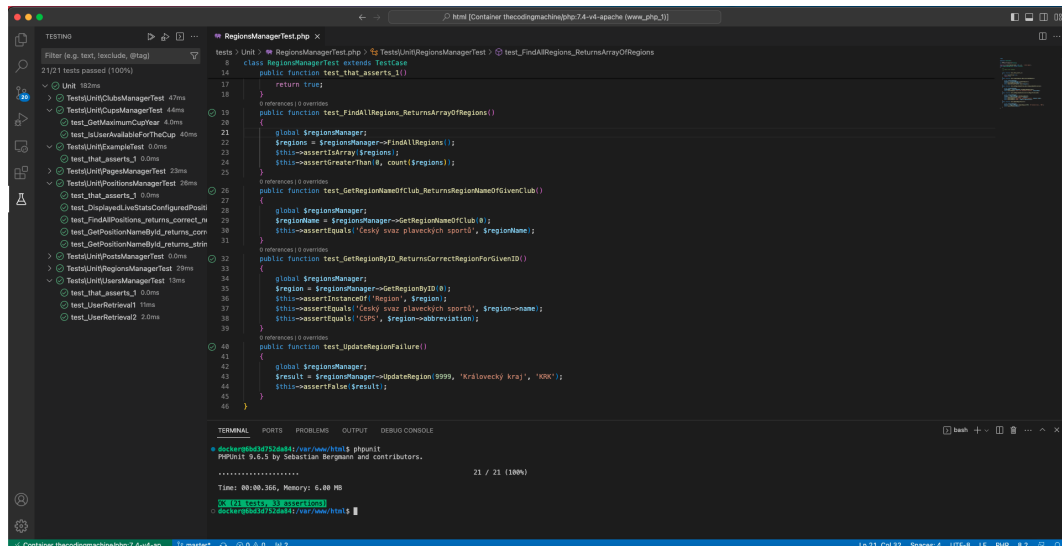


Figure 4.2: Attached VS Code to container and running PHPUnit tests.

<sup>4</sup>CRUD = Create, Read, Update, Delete

<sup>5</sup>Volume within . : **/var/www/html** is, in fact, our working folder.

<sup>6</sup><https://www.devsense.com/en/features#vscode>

### 4.3.2 GitHub Actions workflow

We then load our project repository with folder with tests and proceed to let automated testing be done upon code push into the repository. After testing is done, we can see results of all steps and if nothing failed green checkbox gets added to our repository header next to hash as a bonus.

**Steps that are crucial for our CI pipeline's QA<sup>7</sup> purpose:**

1. code gets pushed into master brach of the repositor<sup>8</sup>,
2. GitHub Action workload<sup>9</sup> gets triggered,
3. creates database, fill it with dummy data, app connects to it,
4. then **phpunit** command is run,
5. **results are reported** for preview for us (Figure 4.3).

Result of all these steps are visible on GitHub website. All steps are openable for more deliberate investigation.

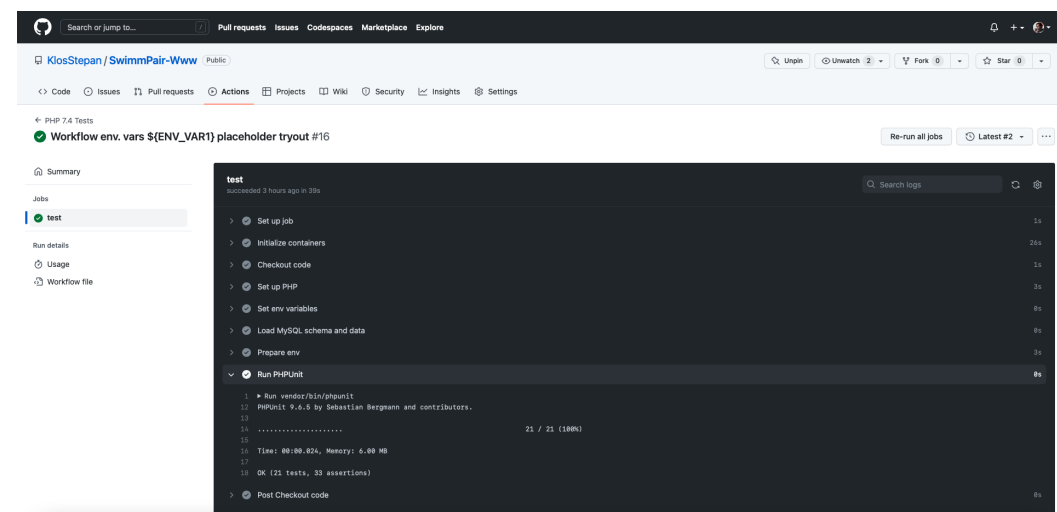


Figure 4.3: GitHub Actions workflows - steps of execution, phpunit step.

Once the pipeline runs successfully, a checkbox appears next to the commit hash, providing a quick overview.

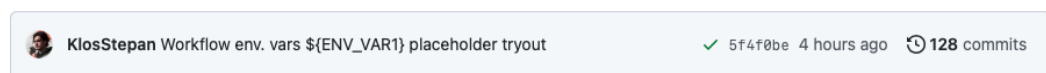


Figure 4.4: Green checkbox next to the commit hash.

<sup>7</sup>QA = quality assurance

<sup>8</sup><https://github.com/KlosStepan/SwimmPair-Www>

<sup>9</sup><https://github.com/KlosStepan/SwimmPair-Www/blob/master/.github/workflows/main.yml>

## 5. Deployment

Development of our application was performed locally using **docker-compose** to glue up 4 components necessary to sufficiently work PHP container for web application, MySQL container + Adminer container and Redis container.

We have to, however, run our application in **Kubernetes Cluster**. **Services** and **Deployments** have to be written, Services for purposes of routing and taking care of newcontainer spawn addresses and Deployments to describe container definitions - images & volumes, replica numbers and environment variables. **Database** is run as a separate standalone entity within the Cluster with persistent storage. **Redis** for syncing and perserving sessions as well.

### SwimmPair running in the Kubernetes Cluster

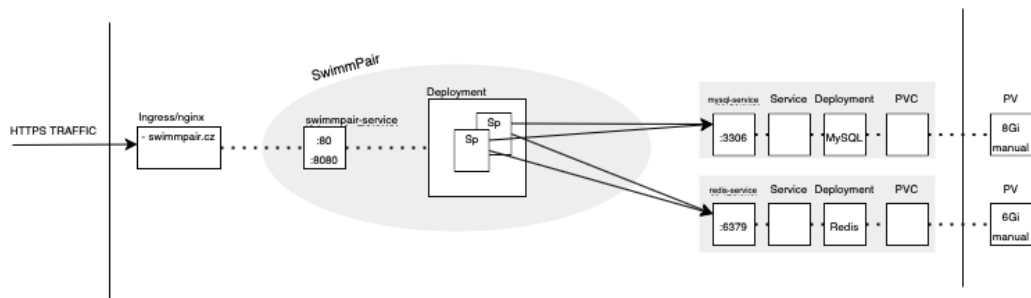


Figure 5.1: Preview of our Kubernetes setup w/ SwimmPair.

Both **Database** and **Redis** can be substituted by Managed Databases<sup>1</sup> or their equivalents in different cloud providers. They can be accessed remotely as dedicated self-hosted services within company for example.

**SwimmPair** can be run using Container Service or "1-click app" as well.

### Dockerization of SwimmPair

File called **Dockerfile** has to be created in the project folder.

```
FROM thecodingmachine/php:7.4-v4-apache
COPY —chown=docker . /var/www/html
```

This image of PHP7.4/Apache<sup>2</sup> was chosen because it correctly dockerizes part of so-called LAMP stack. In order to build this image and push it into Docker-hub.com we run these commands:

```
docker build -t stepanklos/swimmpair .
docker push stepanklos/swimmpair
```

This image is then pullable as stepanklos/swimmpair by Deployment<sup>3</sup>.

<sup>1</sup><https://www.digitalocean.com/products/managed-databases>

<sup>2</sup>Image **thecodingmachine/php:7.4-v4-apache** by TheCodingMachine - <https://github.com/thecodingmachine/docker-images-php>

<sup>3</sup><https://hub.docker.com/repository/docker/stepanklos/swimmpair/general>

# Kubernetes

We run 2 replicas on 2 Nodes in order to ensure reliability and uptime. For further inflow an autoscaler was setup.

## Autoscaling - traffic inflow

```
apiVersion: autoscaling/v1
kind: HorizontalPodAutoscaler
metadata:
  name: swimmpair-autoscaler
spec:
  scaleTargetRef:
    apiVersion: apps/v1
    kind: Deployment
    name: swimmpair
  minReplicas: 2
  maxReplicas: 5
  targetCPUUtilizationPercentage: 70
```

Figure 5.2: Autoscaler for Deployment to accomodate larger application traffic.

## Deployment app-swimmpair.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: swimmpair
spec:
  replicas: 2
  selector:
    matchLabels:
      app: swimmpair
  template:
    metadata:
      labels:
        app: swimmpair
    spec:
      containers:
        - name: swimmpair
          image: stepanklos/swimmpair:latest
          securityContext:
            allowPrivilegeEscalation: true
          ports:
            - containerPort: 80
          env:
            - name: MESSAGE
              value: Hello from swimmpair Deployment!
            - name: DATABASE_HOST
              value: 'mysql-service'
            - name: DATABASE_USER
              value: 'root'
            - name: DATABASE_PASS
              value: 'heslo'
            - name: DATABASE_NAME
              value: 'plavani'
```

```
– name: PHP_INI_SESSION__SAVE_HANDLER  
  value: 'redis '  
– name: PHP_INI_SESSION__SAVE_PATH  
  value: 'tcp://redis-service:6379?auth=aGVzbG8='
```

## Database and Redis

As mentioned our application doesn't come with Database (and Adminer) nor with Redis - we had to set up them separately using PV (persistent storage) on which a PVC (persistent volume claim) was made. Due to Digital Ocean's PersistentVolume implementation policy we had to run these Services as 1 Pod with manual volume - which is sufficient for our workload.

These two services we set up are internally accessible:

- MySQL Database<sup>4</sup>: **mysql-service:3306** ,
- Remote Dictionary Server: <sup>5</sup> **redis-service:6379** ,

in our Kubernetes Cluster.

---

<sup>4</sup><https://github.com/KlosStepan/DOKS-configs/tree/main/mysql-deployment>

<sup>5</sup><https://github.com/KlosStepan/DOKS-configs/tree/main/redis-deployment>

# Conclusion

The process of designing, developing, and shipping this web application was overall successful, although there are still some parts that could be improved or extended in the future. However, our system is ready for these changes and we have learned valuable lessons along the way.

In particular, the design and development process was not as straightforward as we had initially anticipated. Instead, it was an iterative process that required close collaboration with the system requester. The stages of iteration were roughly as follows:

1. Problem description and basic page layout programming (homepage, cup, user, club).
2. Formalization of the model and proper division of code into system objects and task functions.
3. Analysis of user and club data, additional pages for categorization purposes.
4. Addition of regions for further extensible hierarchization.
5. Major final refactoring of the database, backend, and testing with dummy data insertion and querying.
6. Cloud readiness, Docker image of the web application, and Kubernetes deployment.

In the future, the system can be extended by adding new public pages, statistical queries, and administrative tasks. These modifications might involve adding new pages, adjusting the model, or making minor design changes. Thanks to the divided code, these changes can be easily accommodated and will reside in the project GitHub repository <sup>6</sup>.

Overall, we are pleased with the outcome of this project and look forward to seeing it evolve further in the future.

---

<sup>6</sup><https://github.com/KlosStepan/SwimmPair-Www>

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# List of Abbreviations

**CSPS** Cesky Svaz Plaveckych Sportu, *Czech Swimming Federation* unites swimming clubs in the Czech Republic and provides competitions infrastructure and operations.

**LAMP** Linux Apache MySQL PHP, standard stack for running applications.

**SUS** System Usability Scale, is a standardized questionnaire consisting of 10 questions, which assesses the usability of a web application on a scale of 0-100. It provides a measure of how easy the application is to use, helping to identify areas for improvement.

**DOKS** DigitalOcean Kubernetes, managed Kubernetes service by <https://www.digitalocean.com> with various products, scaling and functional options.

**SwimmPair** Swimming Pairing, application that we developed and abbreviated and branded it like *SwimmPair*.

**UML** Unified Modeling Language, style of represent class relations between modelled objects in functional design.

**CRUD** Create Read Update Delete, set of basic functions for performing I/O of data via Managers in web applications.

**CI** Continuous Integration, is a software development practice that involves frequently integrating code changes from multiple developers into a shared repository. It aims to detect and resolve integration issues early by automatically building, testing, and validating code changes. This helps to ensure that the software is always in a working state and ready for deployment.

**K8s** is a shorthand way of writing "Kubernetes". The "8" in "K8s" represents the eight letters between the "K" and the "s" in "Kubernetes".

**QA** auality assurance, refers to the process of ensuring that a product or service meets a certain level of quality and reliability.