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BACHELOR THESIS

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**Web application for swimming
competitions management**

Department of Software Engineering

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Sth

I declare that I carried out this bachelor thesis independently, and only with the cited sources, literature and other professional sources. It has not been used to obtain another or the same degree.

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In date
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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

Being born in mid 90s has given me the opportunity to observe development of personal computing and advent of internet first-hand. By the time I was three I was fortunate enough to experience my father's first computer running Windows 98. By the time I was five I already knew I wanted to be a programmer when I grow up. I realized that I could write some lines and make a public website. I've been fascinated by stories of Microsoft and Apple. These companies put computers on our tables and iPhones in our pockets. This is, however, just brief overview of my motivation about IT world.

Why web applications

Dot-com bubble crash was correction of overhyped optimism stemming from new technologies in early 2000s, subsequently helping whole industry to mature. It was year 2008 and financial crisis that brought the real opportunities in the web space. Despite having made an average American customer poorer, it has brought the world new trend of money saving services that were meant for cutting the cuts or making extra cash. To save money, one didn't call a taxi but UBER operated by another individual on the other side. To make extra money one started renting an extra room at Airbnb. Distrust in banking industry and monetary policy created Bitcoin. It is not hard to see that some of these things are not as technically complicated as one would think. A good software engineer should be able to deploy MVP of each thing previously mentioned in couple of weeks or months.

Motivation

This thesis is a fullstack web application meant for my fellow friend to save him time for more important tasks which he has to perform as a chief swimming referee and club manager. This is valuable training for me since I have to forge a solution of problem vaguely resembling one of the MVPs listed above. Having delved into this problem rewarded me with valuable experiences, insights and lessons. These lessons are hopefully going to help me in my future endeavors and career.

Software engineering is a crucial craftsmanship for delivering positive changes in contemporary world. Building things is this modern adventure.

1. Status quo and solution

Section dedicated to description of problem and proposition of our application.

1.1 Problem description

A friend of mine reached out to me to ask me in order to ask if I could automate part of his agenda work agenda. Administration of swimming competitions and creating statistics is very repetitive and error-prone list of tasks. However, almost all the tasks are executed in same straightforward order.

The Czech Swimming Federation ¹ structure has to be modeled as objects in the application and database records as a storage. Thus, logical structure should be decided and implemented. Swimming referees belong to clubs, clubs are located in geographical regions. Swimming cup is hosted by club. Each club contains dozen of swimming referees and one of them is a club manager. When a cup is online each referee can sign himself or herself up as available for the cup. Club manager can also sign up members of his club for to attend a cup. At the end of the day, organizer of the cup assigns available referees to positions (dedicated task-related roles during cup) that he finds them suitable for. My friend, the chairman of referee committee should be able to perform additional administration related to the database as whole - such as adding and removing users, creating new clubs and modifying whole structure. Administrator can also notify all visitors by posting news displayed on homepage. The SwimmPair system

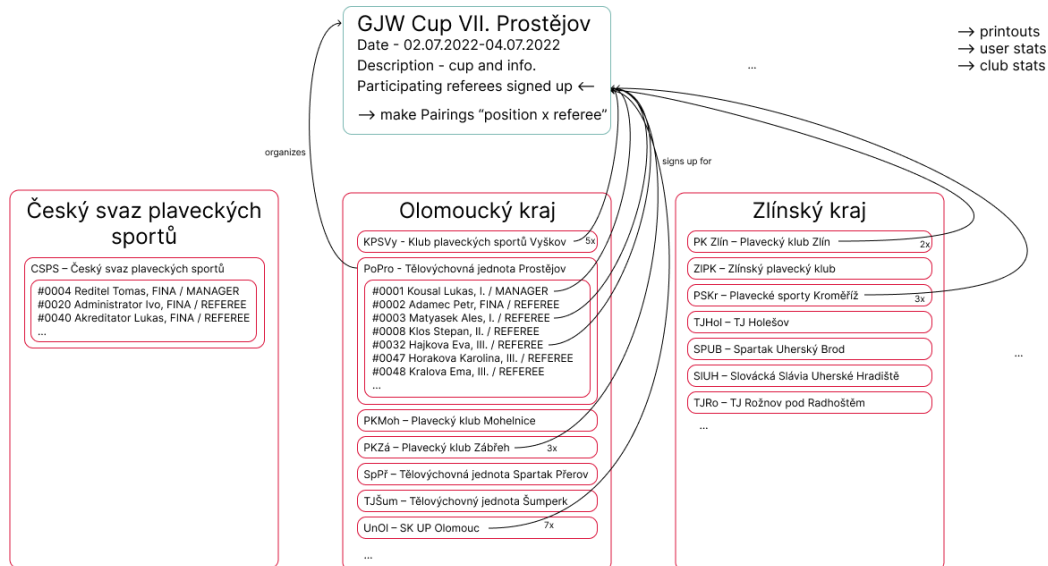


Figure 1.1: Preview of grouping Regions-Clubs-Users and Cup.

should deliver public listing of all **users**, **cups**, **news**, **individual statistics** and **club statistics**. System should allow to browse stats on a yearly basis. Structure from this image then has to be appropriately modeled with objects. Proposition of database schema will be shown further down.

¹<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 organized better to some extent thanks to this application. Interested stakeholders are:

- **Czech Swimming Federation** - organization for swimming,
- **Olomouc Region, Zlin Region** - regions administered together,
- **Lukas K** - manager who demanded this application.

Users of application

Our users are Czech Swimming Federation members. If their **region is participating in this application**, clubs and referees from this region must be in our system. With regards to referee's competence level within these clubs, one will have one of these roles:

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

Roles are self-descriptive and previously casually mentioned. My friend, who came up with this idea is **system administrator** because he's been running all this agenda offline. Club managers are taking care of competitions on behalf of the club and referees are common people who have some degree of knowledge about competitions. Collected statistics will then be used for accreditation granting, activity monitoring and categorization overall.

We were iterating form and features of the web application with two future system administrators during time of development. We then tested usability on all three groups of users via. SUS ² questionnaire.

1.3 Functional requirements

There are some related bundles of tasks that we would like to solve within our application by implementing features and pages to solved them.

²**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.

”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 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 with swimming cup to happen]

”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 management] in order to [keep referees up-to-date]
3. [referee] needs to [view statistics of referees] in order to [have track record about participation]
4. [club manager] needs to [view statistics of clubs] in order to [have information about performance of own club]
5. [club manager] needs to [perform club management] 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 application]
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 happenings (within application)]
2. [stakeholder] needs to [have overall categorization of federation] in order to [use system for administrative purposes]
3. [stakeholder] needs to [have database archivation of federation] in order to [use system as archivation tool]
4. [stakeholder] needs to [have information about participations] in order to [grant accreditations to referees]
5. [system administrator] needs to [publish news] in order to [notify everybody about new things]

6. [system administrator] needs to [edit page/s] in order to [change public info page]

1.4 Domain model

Let's go through entities that have to be represented in our system one by one starting from the most important ones. We will outlay entities and their relations. After that basic idea of entities and their relations will be established we proceed to project specification for further implementation endeavours. We, however, worked more iteratively so this is just retrospective domain model for implementation that we were specifying during the time of development.

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**, assigning referees for specific tasks (time tracking, computer support, head of the cup, 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 over 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 the archive to be revisited for statistical purposes.

Referee

Referee is a person and main workforce during swimming competitions. Referee is a member of Club and participates on it's behalf in Cup. Referee has one of ranks ³. Referee is assigned one or more Position/s, such as timekeeping or pc support and is charge of.

Club manager

Club manager is usually one person who is in charge of administration of Club. Club manager organizes Cup on behalf on Club and acts as main figure during it. Club manager can also help with some work (Position), however, more they are more of an administrative character, if ever. Club manager completes pairing and plans everything.

Coordinator

Coordinator is a person who is head of swimming in specific region. He budgets, plans tournaments, manages administrations and whole database of referees, clubs and cups. He's person of highest administrative importance.

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

Club

Club is an administrative unit grouping people (in the same city). Club has a specific name, abbreviation and ID in Czech Referee Federation. An image can be included as well. A club will be serving as a formal authority organising Cup by a User who is club manager. Club is unanimously affiliated to Region. Statistics regarding performance of members of Club at swimming competitions must be implemented. Statistics have informative characted and will save time in the current status quo - keeping track of presence and work descriptions in Excel spreadsheets.

Region

There are 13 regions of the Czech Republic, we are solving this problem for 2 that are being adminstered together. Maybe we will do more. Clubs are located in one of these regions. When new Club starts using SwimmPair in the future, new Region has to be added and potential clubs created and attached to this Region.

Pairing

Pairing is simple list of pairs (**Referee** x **Position**) \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 connections

Majority of focus should be on **Referee**, **Club manager** and **Cup** in the presented schema. Referees belong to Club that belong to Region. 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 specifies position. Referees must be available in specific time but **Pairing** is where each record can be assigned a position from prescribed **Positions**.

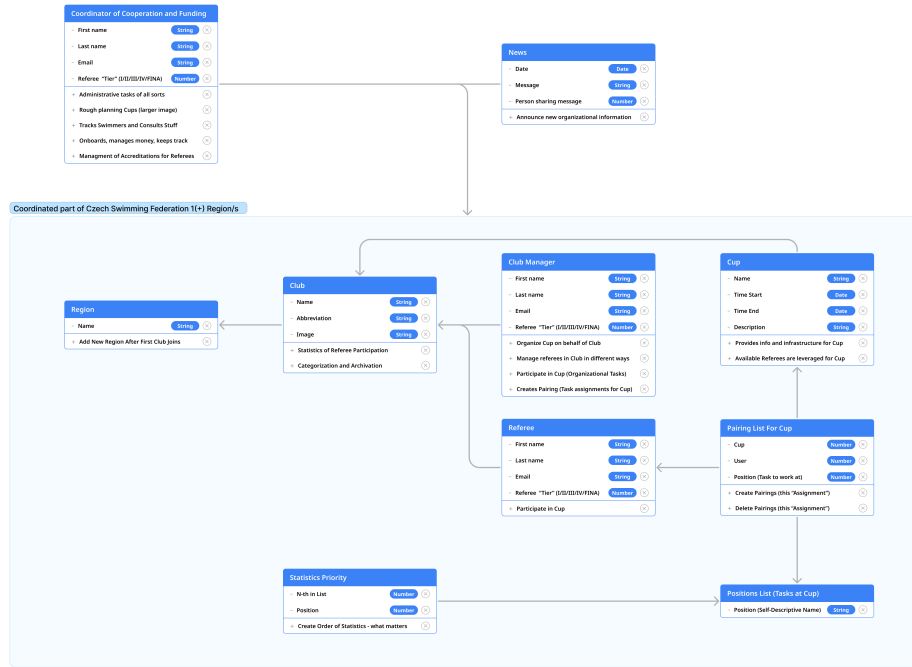


Figure 1.2: UML Class Diagram outlaying the situation

1.5 Quality/Usability Requirements

Several good practices have to be implemented to make SwimmPair easy to use. These practices are either well known or situation specific but they have one thing in common - they should make the application good to use.

Smooth frontend browsing

Frontend of SwimmPair should be easy to use. There are several options and use cases of JavaScript that can come in handy. Reduction of page reloads is definitely a good way to go. Therefore there are going to be asynchronous JavaScript calls for obtain semi-partial data. After, next function will modify the DOM based on data received from asynchronous call.

Multiple device types

Today is certain that there are users who want to browse our system from pc, tablet or smartphone and responsive design is a necessity. Since CSS3 supports media queries⁴ we are going to use them for creation of 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 printed⁵ from website and hanged as data printout.

Appropriate design

Red blue and grey are colors that appear pretty much at a swimming pools. These colors will be used in our system as well. The elements should have fresh lightweave look and not appear heavy.

1.6 Scalability/Usability Requirements

Application that we are preparing is going to be used for 2 Regions and approximately 100 referees. Maximum scaling would be whole Czech republic, that means 5-6x larger load than the current one, which shouldn't be problem on LAMP stack. We can always scale up number of Kubernetes

⁴https://developer.mozilla.org/en-US/docs/Web/CSS/Media_Queries

⁵https://developer.mozilla.org/en-US/docs/Web/CSS/Media_Queries/Using_media_queries#targeting_media_types

2. System design

Reader will be familiarized 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. Therefore we came up with a concept of managers. Each page of SwimmPair is composed of same 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 are used to implement SwimmPair application:

- **HTML** is HyperText Markup Language ¹ - application pages are templated in HTML by PHP,
- **CSS** is Cascading Style Sheets ²,
- **PHP** is a general-purpose scripting language geared toward web development ³ - object model and backend services are provided by it,
- **JavaScript** is a general-purpose scripting language that conforms to the ECMA Script specification ⁴,
- **MySQL** is an open-source relational database management system ⁵,
- **Git** is a distributed version control system: tracking changes in any set of files - this project is versioned and kept in public GitHub repository ⁶,
- **Docker** is a set of platform as a service products that use OS-level virtualization to deliver software in packages called containers ⁷ - used for deployment of our application,
- **Kubernetes** is an open-source container orchestration system for automating software deployment, scaling, and management ⁸ - used for production deployment of our application into cluster.

¹[WHATWG, 26 December 2022]

²[W3C, 31 December 2022]

³[The PHP Group, 28 November 2019]

⁴[INTERNATIONAL, June 2022]

⁵[Oracle, 2023]

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

⁷[Inc, 2023]

⁸[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.

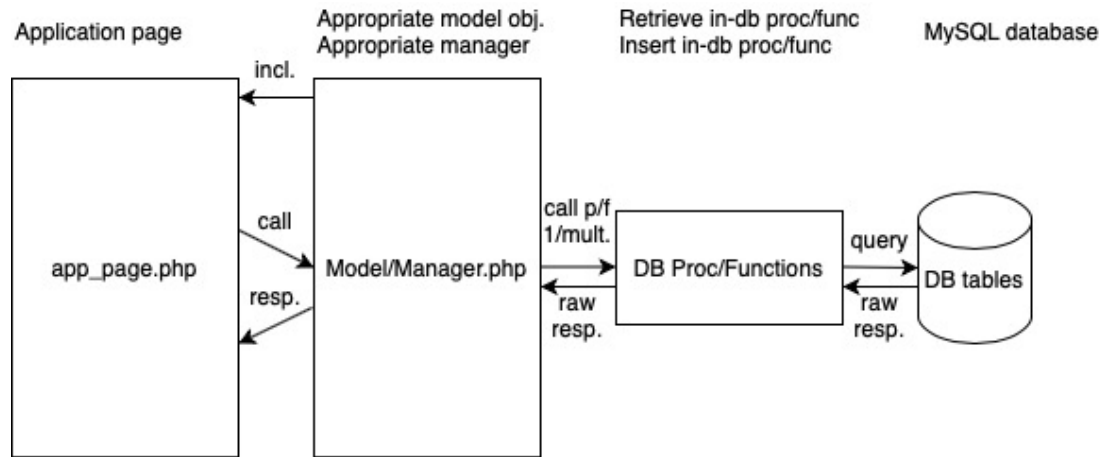


Figure 2.1: From page to manager, database, function, database and back.

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 of some public and private parts of our application. They serve as an initial visualization mockups based on which the real UI will be made. These mockups are not 1:1 guidance, rather an idea for reader and stakeholders for the beginning.

Public website mockups

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

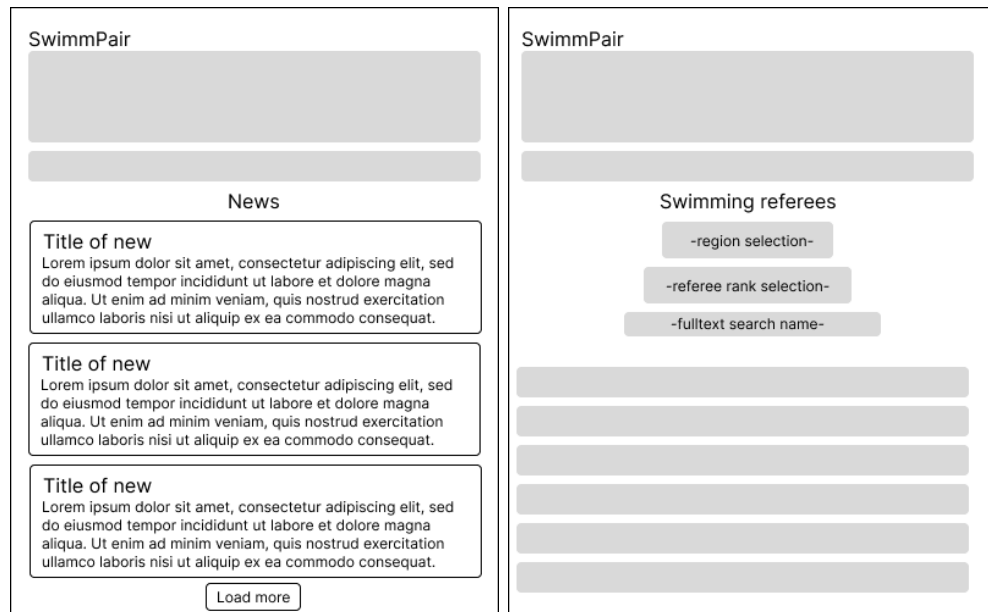


Figure 2.2: Public pages - homepage (S5) and listing of users (R3/S4).

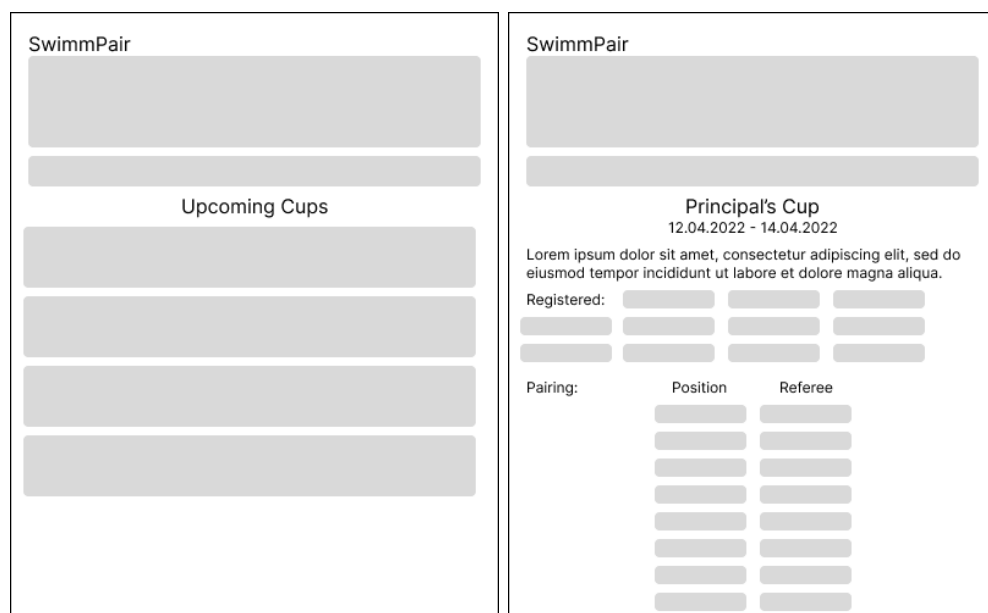


Figure 2.3: Public pages - cups listing and cup preview (C3).

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 is a dashboard layout. At the top, it has 'SP' on the left, 'Welcome' in the center, and 'Settings' on the right. Below 'Welcome' is the section 'ADMINISTRATIVE TASKS' followed by a list of ten horizontal bars. Below this is 'MY CLUB' with two horizontal bars, and 'MY REFEREE PARTICIPATION' with one horizontal bar. The right mockup is titled 'Edit Page' with a back arrow on the left. It contains 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 is titled 'Add Cup' with a back arrow on the left. It has a 'Cup name' field, 'Date start' and 'Date end' fields, an 'Organizing club' field with the placeholder '-name of user's club here-', and a large 'Description of cup' text area. An 'Add Cup' button is at the bottom right. The right mockup is titled 'Cup name' with a date '08/08/2020' and a 'PREV' button on the right. It shows a list of 'Available referees' with several horizontal bars. Below this is a 'Main referee' field and a 'Starter' field. Arrows indicate a drag-and-drop action from the 'Available referees' list to the 'Main referee' field. There is also an arrow pointing to the 'Starter' field. An ellipsis '...' is at the bottom.

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

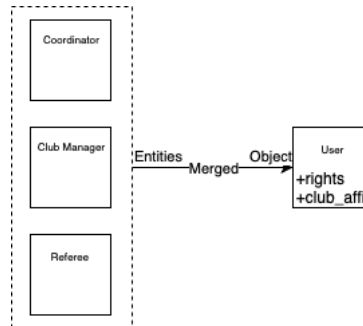


Figure 2.6: These 3 people entities got merged into the single object.

Pairing entities to objects

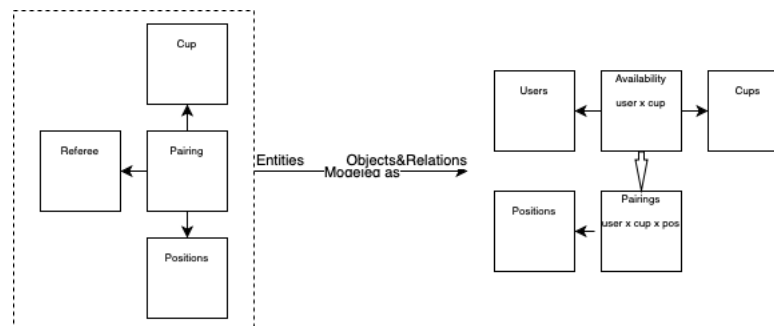


Figure 2.7: Entities modeled as 3 objects and 2 relational tables.

Remaining entities

Mapping of remaining entities is self-evident.

Full database schema used for out application

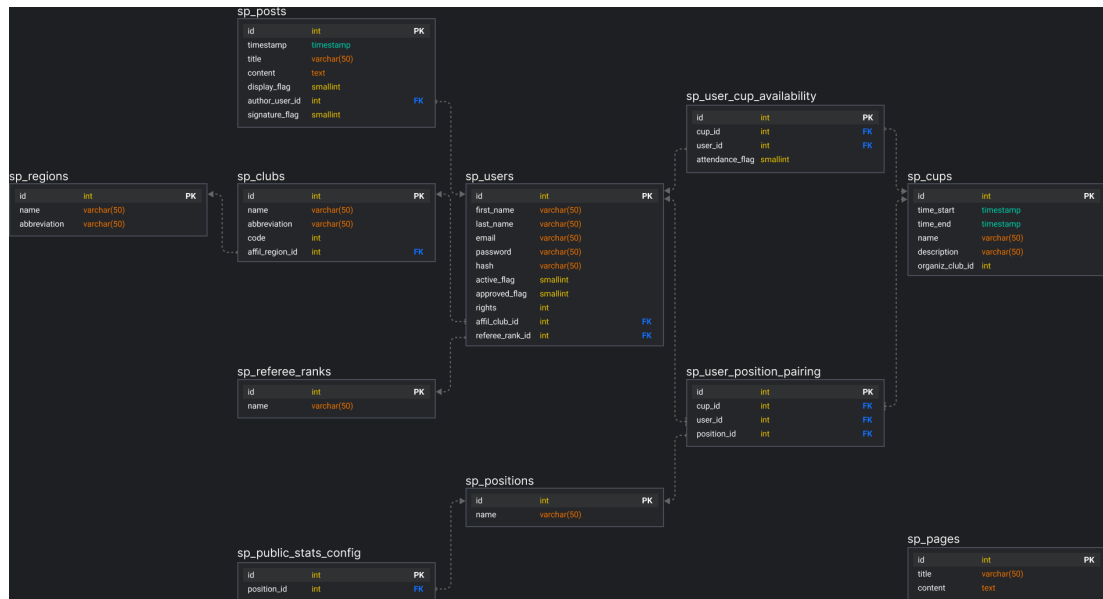


Figure 2.8: Full database schema for the SwimmPair application.

2.6 Functional requirements mapping to API

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

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

⁹http://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 ¹.

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)

¹<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.

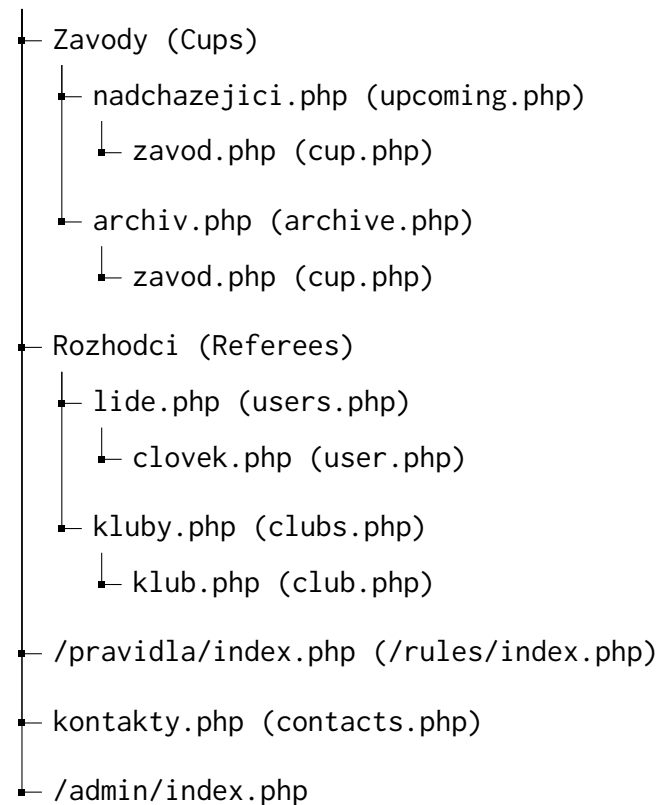
```
/*Database credentials from environment*/
$host = getenv("DATABASE_HOST");
$user = getenv("DATABASE_USER");
$pass = getenv("DATABASE_PASS");
$db = getenv("DATABASE_NAME");
/*Database connection and charset set*/
$mysqli = new mysqli($host, $user, $pass, $db) or die($mysqli->error
);
$mysqli->set_charset('utf8');
/* Sanitization function */
function h($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 equivalents 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



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 that 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 functions documentation

Several features of public website implemented for interactive browsing.

Library js/SwimmPairFrontendJSLib.js

This library is created to support Ajax calls and DOM operations on frontend. Functions are self-descriptive and **this** means reference to caller DOM element.

- **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)

XMLHttpRequest endpoints

- 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

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**. If the result is

- i) **null** button is deleted since there are no other articles to pull from DB,
- ii) **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 **UpdateClubStatsTable(returnedGetJSON)** which literally updates stats.

3.6.4 Filtering referees

This function is triggered by one of these:

- i) **RegionPickerChanged(this)**,
- ii) **RefereeRankPickerChanged(this)**,
- iii) **SearchBarChanged()**.

Registrovaní rozhodčí

VŠE OLK ZLK

VŠE I. II. III. FINA

Hledat...

Adamec Petr I. Olomoucký kraj

Figure 3.1: Filtering of users ui preview.

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[])** (referee area id), **Rank** **IsOptionPermissible(rrid, args[])** (referee rank id) and then if one's Name **IsNamePermissible(args[])**. We then set one's element style to **style=""** and continue cycle execution. If we fail one of these three conditions we proceed to code below which sets element style to **style="display:none"**.

```
...
//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**¹ 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>

¹In <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 questionnaire 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 ².

Questionnaire 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 calculated³ SUS feedbacks based on responses from 20 people.

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

²John Brooke [1995]

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

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.

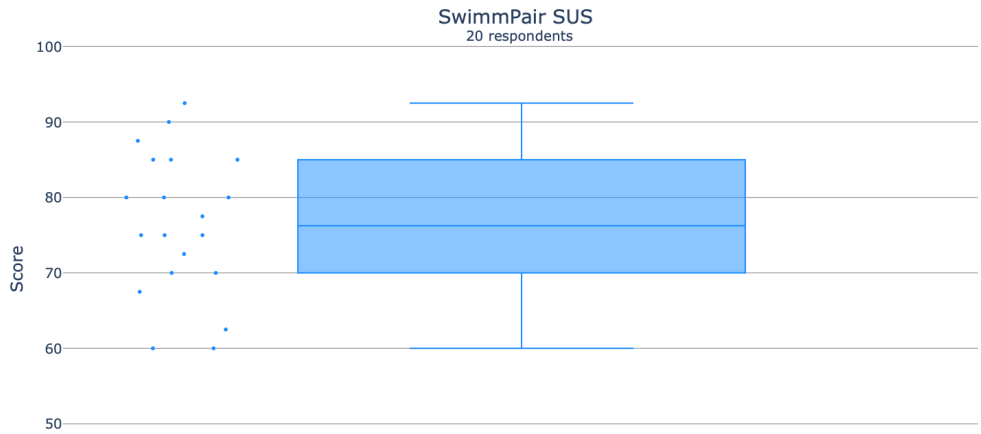


Figure 4.1: Boxplot of scores.

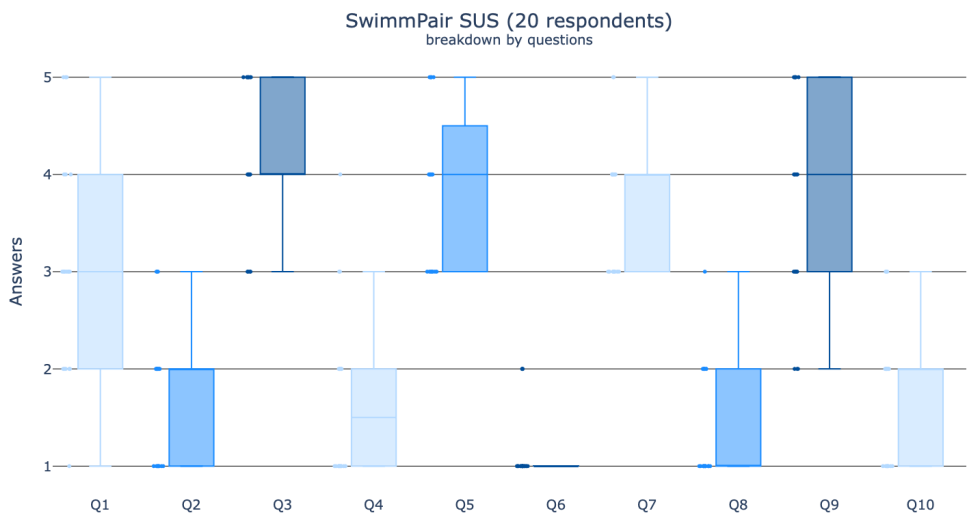


Figure 4.2: Breakdown of single questions.

4.3 Unit testing

Testing serves two puposes.

- i) **Firstly**, to ensure that functionality works as intended.
- ii) **Secondly**, not only that new functionaly works as intended but also that any previous stuff or functions were not broken either.

We wrote bunch of PHPUnit tests for each Manager called ManagerTest.php in folder **tests/Unit** in our project. These tests test ordniry CRUD⁴ functionalities.

4.3.1 Local execution of tests

See results of test during local development by following these steps: attach VS Code to running Container⁵ and see results in PHP Tools by DEVSENSE⁶. We can open command line - **docker@6bd3d752da84:/var/www/html** and run tests by typing **phpunit** to the command line.

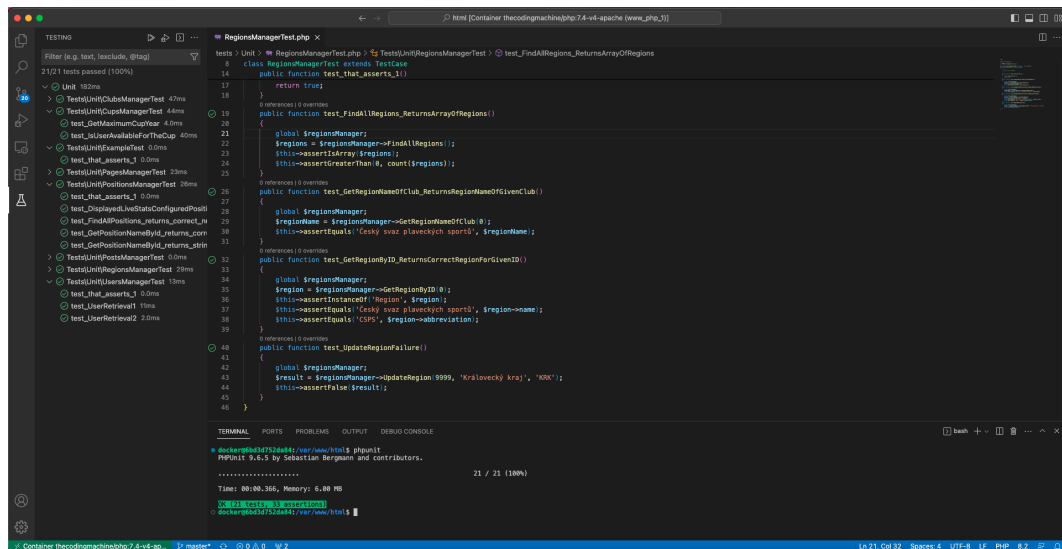


Figure 4.3: Attached VS Code to container and run tests via PHP Tools.

⁴CRUD = Create, Read, Update, Delete

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

⁶<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.

Our testing pipeline works as follows:

- code gets pushed into master brach of repository,
- GitHub Action workload gets triggered,
- creates database, fill it with dummy data, app connects to it,
- then **phpunit** command is run.

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

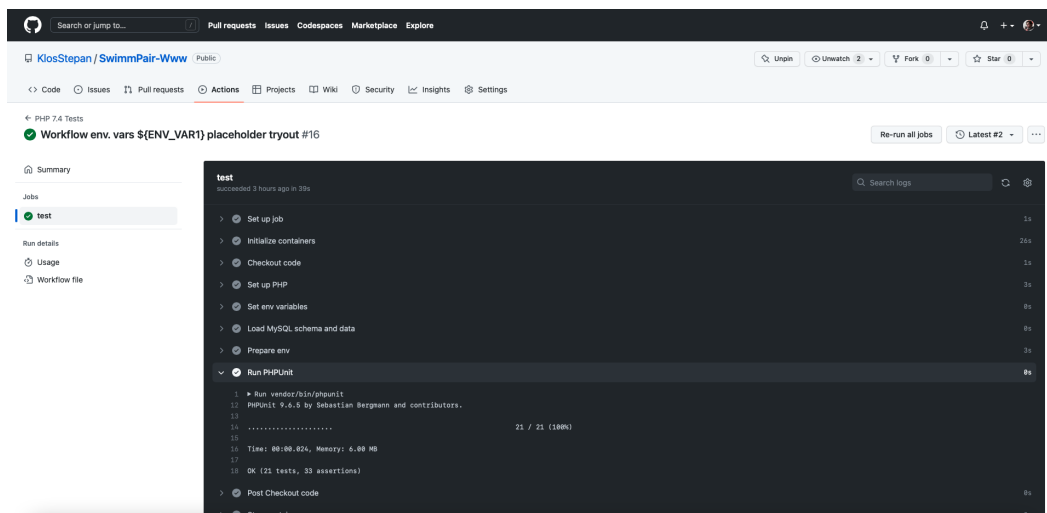


Figure 4.4: GitHub Actions workflows - steps of execution, opened phpunit.

After all tests are run successfully and nothing fails along the way also, checkbox is placed next to commit hash.

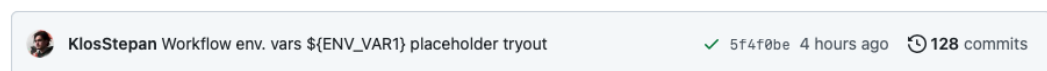
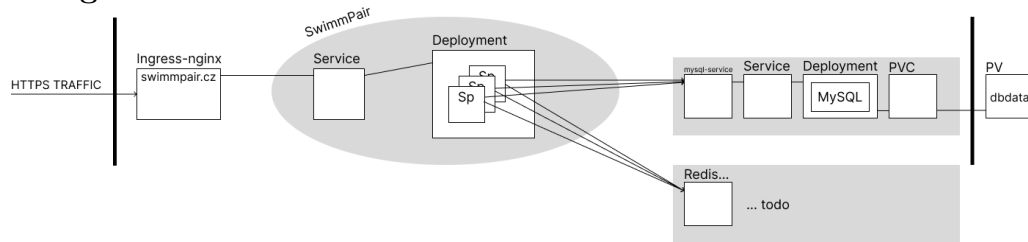


Figure 4.5: Check next to commit hash after successful test pipeline.

5. Deployment

Development of our application was done locally - using **Docker compose** to glue up three components necessary to sufficiently run our system - PHP runtime for web application, MySQL Database and Adminer. We have to, however, run our application in Kubernetes Cluster. **Service** and **Deployment** have to be written, Service for purposes of routing and taking care of container spawn addresses and Deployment to describe container replicas and appropriate images. **Database** is run as separate entity within the Cluster.

Running SwimmPair in Kubernetes Cluster:



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 Apache/PHP¹ was chosen because it correctly dockerizes part of so-called LAMP stack. In order to build this image and push it into Dockerhub.com we run these commands:

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

This image is then pullable as stepanklos/swimmpair from Deployment.

Kubernetes

We run 2 replicas on 2 Nodes in order to ensure reliability and uptime.

Database and Redis

As mentioned before, our application doesn't come with Database and Adminer, which have to be set up separately using persistent storage PV on which we write PVC and reference from deployment.

Redis - !TODO

¹Image **thecodingmachine/php:7.4-v4-apache** by TheCodingMachine - <https://github.com/thecodingmachine/docker-images-php>

Conclusion

Endeavor of designing, development and shipping of this web application was overallly successful. There are some parts, that can be improved or extended in the future, however, our system is ready for this and lessons have been learned.

Speaking of lessons, design/development part was not as straightforward as theoretics would have appreciated, but rather it was done iteratively with cooperation of system requester.

The stages of iterations are roughly:

1. Problem description + basic pages layouts programming (homepage, cup, user, club).
2. Model formalization and proper division of code into system objects and task functions.
3. Statistics on data (user, club), additional pages for categorization purposes.
4. Addition of Regions for futher extensible hierarchisation.
5. Major final refactoring of database, backend and testing with dummy data insertion and querying.
6. Cloud ready, Docker image of web application and Kubernetes Deployment.

Further system extesions might be related to adding **new public pages, statistical queries, administrative tasks addition** - these are pages addition, model adjustment and minor design changes. All types of modifications can be accomodated thanks to divided code and the changes might consist of modifying style, model classes enhancement, database procedures addition etc. Future modifications will reside in the the project GitHub repository ².

²<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 web applications.

SUS System usability scale, standard 10 questions questionnaire evaluating on scale 0-100 how good to use the web application is.

DOKS Digital Ocean Kubernetes, managed Kubernetes service provided by <https://www.digitalocean.com> with various scaling and functional options.

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

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