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Soccer Analytic Tool

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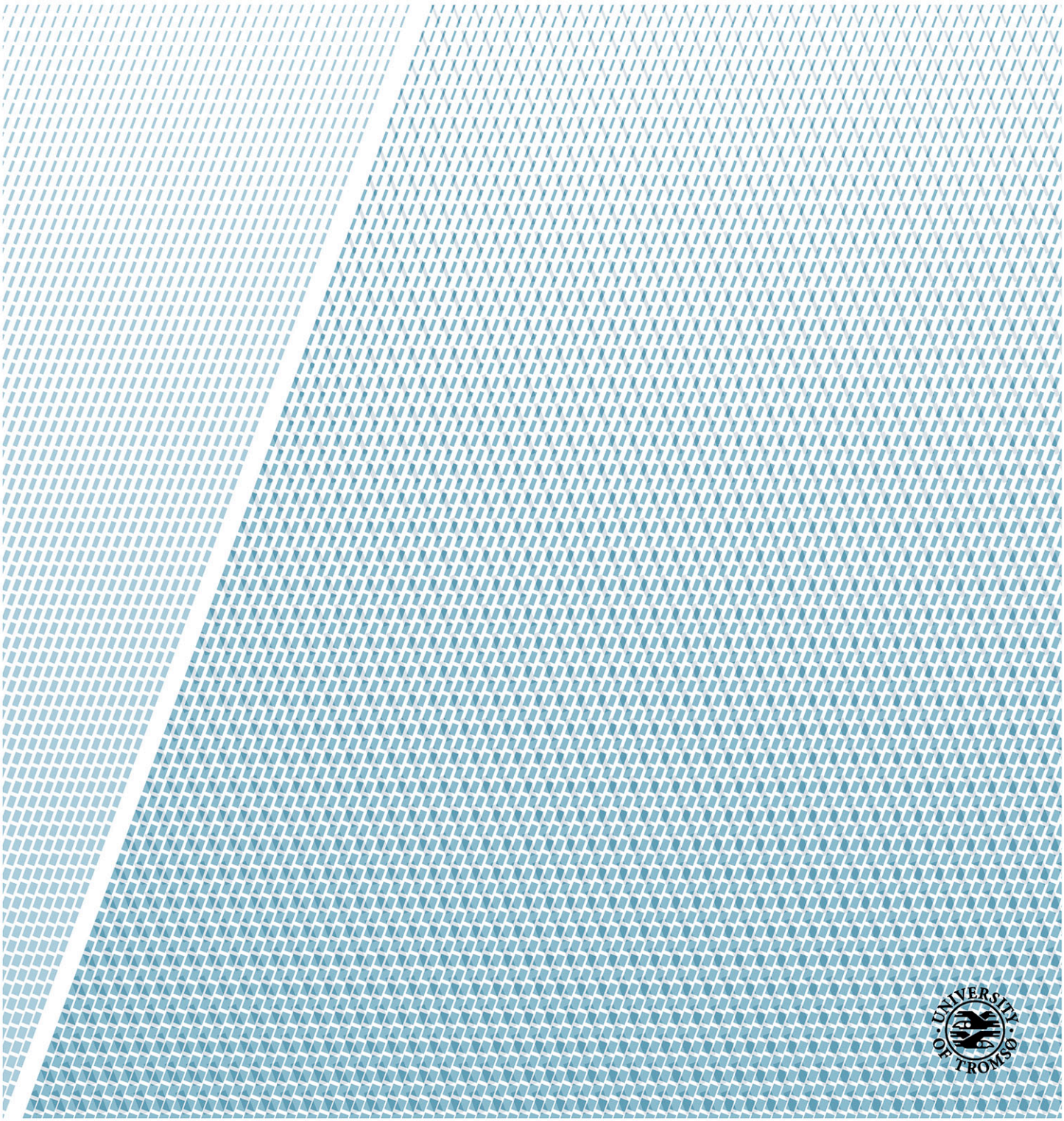

Abstract

Sports science is an increasingly hot topic and more and more soccer teams are investing time and money into strategic development of big data and sports science. All this to increase players performance on the field and reduce the risk of injuries. Soccer teams and athletes in general are constantly looking for possibilities to gain advantages over opponents. In soccer your next opponent is analyzed down to the smallest details to find weaknesses and strengths. It is all about winning, and a step on the road to success is to take advantage of the opponents weak points and limit their strengths.

This project creates and evaluates a system for capturing events relevant for soccer opponent analysis and an interface that presents the information gathered.

Acknowledgements

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List of Acronyms

UI User Interface

TIL Tromsø Idrettslag

ZXY ZXY Sport Tracking System

AJAX Asynchronous JavaScript and XML

JSON JavaScript Object Notation

HTML HyperText Markup Language

CSS Cascaading Style Sheets

API Application Programming Interface

REST Representational state transfer

HTTP Hypertext Transfer Protocol

MVP Model View Presenter

DOM Document Object Model

XML eXtensible Markup Language

SPA Single Page Application

CRUD Create Read Update Delete

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Chapter 1

Introduction

1.1 Background

Sports science is an increasingly hot topic and more and more soccer teams are investing time and money into strategic development of big data and sports science [15]. All this to increase the players performance on the field and reduce the risk of injuries. One of the pioneers in this field for a long time, AC Milan, established in as early as 2002 the MilanLab [5]. The goal for the program was to get better and more concrete information about the players physical condition by collecting data over time of players performance. As AC Milan was one of the first to use big data, the use of big data today has exploded. Services like Opta and Prozone serves player statistics, heat maps, and video analytics of players performance. Fans get exposed to these statistics by clubs and broadcasting companies that uses it actively in their coverage of soccer games. The awareness of statistics for clubs and fans has possible never been higher than now [4].

Soccer teams and athletes in general are constantly looking for possibilities to gain advantages over opponents. In soccer, your next opponent is analyzed down to the smallest details to find weaknesses and strengths. All this to be able to take advantage of your opponents weak points and limit their strengths. It is all about helping the players prepare for matches and let them know what to expect from the opponent team. Knowing about typical team plays and player movement can help you prepare for the match.

There are several ways to gather information about your opponent; from looking through a full 90 minutes match, to advanced tools, which can high-

light key information for you. Some of them are expensive as Prozone [16], which is a complete system for capturing and presenting information. For small soccer clubs with relatively small budgets this can be an expensive investment. Another system is Interplay Sports[1], which TIL uses for game analytic. A video feed from any match can be used as the input, letting you manually tag and describe situations in the match. This can also be done live. In a sport where the next soccer match usually is in 3 days tools for filtering out the useless data is valuable.

In the analytic process there are two processes we will look at; first you need to gather the information and secondly is how to present the information gathered.

1.2 Problem definition

This project will develop a system complementing the Muithu and Bagadus systems. Focus will be on soccer opponent analytics, where a data repository needs to be developed capturing important events relevant for this type of analytics. Especially we want to identify the key players offensive in a team. A user interface component presenting the core information about the opponent should also be developed and evaluated.

1.3 Interpretation

The project is providing an infrastructure for capturing events like attacks that leads to an attempt on the opponent goal, and presenting this information through a user interface. We are interested in how long it typically takes to capture all relevant events from a single match, as this has to be done manually. A data model that reflects what we want to capture from each attack, needs to be developed for being able to get relevant information for being used as an opponent analytic system.

First, a requirement specification shall be developed. Then a prototype developed that fulfills the requirements. At last specialists in the domain of soccer shall evaluate the system.

The design and development processes will be performed in collaboration with staff of the Norwegian soccer club TIL. An end-user test of the system

[1] http://www.interplay-sports.com/

against currently used tools and the system as a opponent analytic system will perform a final evaluation, and the result of this evaluation will be used to conclude the project.

1.4 Methodology

The final report of the ACM Task Force on the Core of Computer Science [2] divides the discipline of computing into three major paradigms:

- *Theory*: Theory: Rooted in mathematics, the approach is to define problems, propose theorems and explore to prove them in order to find new relationships and progress in computing.
- *Abstraction*: Rooted in the experimental scientific method, the approach is to analyze a phenomenon by creating hypothesis, constructing models and simulations, and analyzing the results.
- *Design*: Rooted in engineering, the approach is to state requirements and specifications; design and implement systems that solve the problem, and test the systems in order to find the best solution to the given problem.

For this project the design process seems to be the most suitable out of the three paradigms. The design process consists of 4 steps, which are repeated if tests reveal that the latest version of the system does not meet the requirements.

- *State requirements and specification*: A need or problem is identified, researched, and defined.
- *Design and implement the system*: Data models and a system architecture are designed. Prototypes are implemented.
- *Test the system*: Assessment and testing of the aforementioned prototypes.

1.5 Outline

- *Chapter 2*: Presents some related work to the project
- *Chapter 3*: Describes the requirement specification

- *Chapter 4*: Describes the design and implementation of the system
- *Chapter 5*: Gives a demonstration of the system
- *Chapter 6*: Evaluates and discuss the system
- *Chapter 7*: Concludes

Chapter 2

Related work

In this chapter we present some background related to analytic in the domain of soccer. We look at different types of analysis out there. This spans from pre-match to post-match. Then we go into how data is gathered and presented. For gathering of data there are two main approaches: manually often by humans annotating video feeds, and automatic capturing often by installing receivers and having players wear physical sensors for tracking.

2.1 Types of analysis

In soccer there are several phases where you use analytic to help you gain insight. In this section we will look at the typical use cases of analytic. Not only soccer teams use analytics, but also broadcasting companies and fans widely use statistics to build up under their arguments.

2.1.1 Pre-match

Pre-match you use analytic to find weaknesses and strengths in the opponent team, on an individually level or as a team. You look at your team matched up against your opponent. A typical situation is that the manager gets a video summary of the opponent highlighting the opponents strengths and weaknesses. The coaching staff may use tools like Interplay to gather information and create the video summary. Other software like Prozone[1] can

[1]http://www.prozonesports.com/index.html

also likely be used to break down the opponents offensive and defensive play. A deeper introduction to Prozone is given in section 2.2.2

In broadcasting, you have pundits bringing you analytic of key battles during the build up to the game. A typical thing is to look at battles like wingers versus backs, midfield clashes or striker versus central defenders. The battles are often illustrated with statistics or with video clips highlighting aspects of both players game that will be decisive.

Fans are analyzing the game all the time. Except from watching broadcasting companies, they get exposed to analytic via social media. Opta[2] is company that has taken full advantage of social medias. Figure 2.1 is a screenshot of a tweet from one of the many Twitter accounts Opta have to promote themselves.

Figure 2.1: A typical tweet from one of Opta's Twitter account

2.1.2 In match

During match the coaching staff continuously analyze the match and make adjustment. The players make all the decisions in the end, but the coach is the boss and sets the style of play. An adjustment to the teams formation can potentially be the tipping point that wins you the game.

Tromsø Idrettslag (TIL) uses a system Muithu [7] that lets you annotate sequences of a game with entity's like player and comment. This information will then be time synchronized with the video feed. Later, like in at half time or even in the game, you can search on entity's to get the corresponding video feed. It can be anything that has been previous tagged like a player involvement to a team move that was executed perfectly.

Using systems like ZXY Sport Tracking System (ZXY)[3] or MiCoach [15] you can get real time information about a players performance during the match.

[2]http://www.optasports.com/
[3]http://www.zxy.no

Rather than assuming that a player is tiring you can get information metrics that tells you this. You get evidence that the player in fact is fatigued. In soccer you only have 3 substitutions. Making the right ones is crucial in an even match or to avoid injuries.

Using data gathered from sports data company's like Opta you can get statistics live during the game. It is popular in TV to show statistics like ball possession percent, how far players have run or the number of passes played and so on. As mentioned earlier Opta posts many of their statistics to their social media accounts.

2.1.3 Post match

During the post match the coach team goes through the game to evaluate the team performance. This is valuable as you get concrete clips about good and bad involvements on team or player level. You can highlight situations in the match to help players better understand tactical aspects. Interplay Sports[4] is a system used today at Alfheim for this purpose. It is used for analysis of matches in a post-match scenario where you can tag situations in the video.

2.2 Capturing of data

2.2.1 Opta

Opta, one of the big players in the field of sport analytic uses manual input to create their data repository [4]. They have editorial teams across the world that captures data manually for the most popular soccer leagues and other sports. For example, to capture statistics for a single match they have 3 humans annotating. The data is captured via an application specifically created for the purpose of capturing data as quick and easily as possible. The editorial teams of Opta need to be able to identify a player in a very short time to be able to keep up with the pace of the game.

Opta capture all types of actions like passes, type of pass and interceptions to mention a few of them. For each action they log, they add a series of description tags like pitch coordinate, timestamp, which player and team.

[4]http://www.interplay-sports.com/

For every single pass they add descriptors if it was a through ball, normal ball or even as detailed as headed flick on from a long ball. For shots they register the foot it was kicked with, if it was a volley and so on. All this is done while the match is playing. About 1600 individual events are recorded in a standard match. This gives them a very rich database of events and a range of possible queries to run.

```
<Event id="290575408" event_id="5" type_id="1"
player_id="20856" team_id="810" x="44.6" y="61.1">
    <Q id="1774596260" qualifier_id="141" value="91.6"/>
    <Q id="1429253465" qualifier_id="140" value="49.9"/>
    <Q id="1084400575" qualifier_id="56" value="Back"/>
</Event>
```

Above is an example of an event extracted from the Opta database (stripped down). The event has a series of qualifiers describing it. In this example the event is a pass from [44.6, 61.1] to [91.6, 49.9] in Optas co-ordination system.

2.2.2 Prozone

Prozone is a video-based system that tries to track players in team sports [16]. Their data capture system incorporates 8-12 cameras, which is strategically positioned throughout the stadium to cover 100 percent of the ground, but with some redundancy in case of a faulty component. They also incorporate the TV-camera feed, which always follows the ball. All cameras are hooked into one server and uploaded at the end of the game before sent to undertake the tracking process. When the system is installed it required some setup before it is operational; the pitch size needs to be incorporated into the system and cameras calibrated. Figure 2.2 shows the camera location in a soccer stadium.

The coding tracking process of the player's movement and actions is a sort of manual process at present time. First each camera feed goes through each own tracking process determining image co-ordinates and continuous trajectories for each player. The output from all the cameras is then combined into one dataset. Going into the algorithm for this is out of the scope of this project. In the final stage the manual work comes into the loop. There has to be a quality control group of operators dedicated for post processing the game. First, the operators have to map the players identity with their corresponding start location. The operators will then follow the video feed

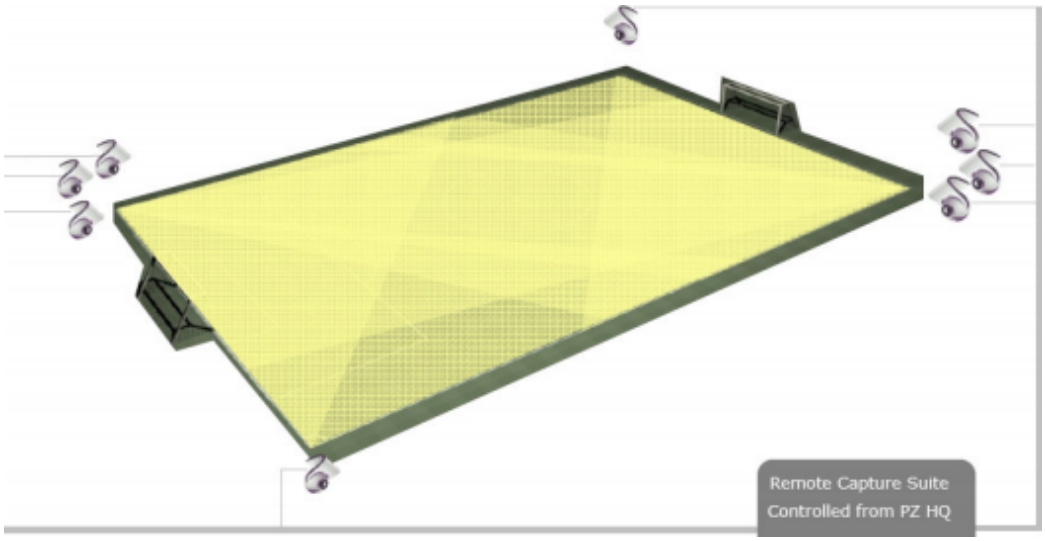

Figure 2.2: The Prozone camera system illustrated. Taken from Prozonesports.com

checking that the identification of all players remains constant during the match. The tracking process may run into problems when two players collide or have any other physical contact as it becomes unclear who is who. To map video image co-ordinates to pitch co-ordinates Prozone uses computer vision homography calibration process.

The whole manual operation by the operators is done in an own software that helps you minimize the amount of manual work for the operators. The software follows rules created by basic machine learning algorithms to validate and verify the input. A simple example would be if the ball goes out of play the system would know that the next event would be a throw in, corner kick or goal kick.

Prozone claims to be able to track every movement of every player on the pitch with a resolution of 10th of a second. This without using any physical equipment on the players. Di Salvo et al. [1] conducted an empirical evaluation of deployed Prozone systems at Old Trafford in Manchester and Reebook Stadium in Bolton, and concluded that the video camera deployment gives an accurate and valid motion analysis. The data after a match is available through Prozone analysis software.

2.2.3 Automatic capturing

A system that uses sensors is ZXY Sport Tracking System. The system is used by premier league soccer teams in Norway, including TIL and Rosenborg BK. Data captured is stored in a Sybase database with each match requiring about 500-700MB storage. The players have to wear a belt around their waist for the system to be able to track their movements. The ZXY system is able to track the players movement very detailed with an accuracy of 0.5m. It has a resolution of 20 samples per second.

The technology behind it relies on a radio-based signaling substrate to provide real-time high-precision positional tracking, also including acceleration and heart rate [3]. An installation of receivers is required for the system to work. The home arena for TIL, Alfheim, is currently equipped with 10 receivers. A receiver tracks a specific area of the soccer field and combined they cover the whole pitch with some redundancy areas. The communication from the belt to the receivers goes on a 2.45-5.2 G Hz frequency radio signal. To compute the positional data the stationary radio receiver uses an advance vector based processing of the received radio signal. The data is aggregated and stored into a relational database. Including the positions of the players ZXY also gives you the step frequency, speed and direction.

Figure 2.3: Overview of the ZXY system with receivers placed around the pitch, and players wearing sensors. Image from zxy.no

2.2.4 Wrap up

The main problem with tracking systems that uses physical sensors is that usually only one of the teams wears the sensors. This limits the functionality of the system as an opponent analysis system. You only get data for one team and if you have installed it at your stadium it captures only half of the matches.

On the other hand you have the manually systems that require human annotation of matches. These systems have the advantage of being able to track both teams. As they rely on human annotation of some degree they get more rich data as well, but requires strict rules of the semantics of the metadata. There has to be some form of quality control of the data captured to ensure correctness.

2.3 Presenting data

This section gives a short overview of how systems present information.

2.3.1 Prozone

Prozone comes with several systems to illustrate data gathered. The most relevant for this project is the opposition analysis system[5], but also several other tools Prozone delivers can be used in opponent analytic. The tools includes features like 2D animation, single player analysis, team analysis, pressing analysis, player tempo, passing movements, receiving the ball and player events. Figure 2.4 shows some of these features.

On individual level you can get basic statistics like shots, total passes, passing success, crosses, shots on target, balls received, tackles and fouls. You can also retrieve all sprints for a player. This could help you prevent injuries. Players in certain areas of the field have more intensive sprints when they first are involved and thus are more vulnerable to injuries. Knowing the actual physical load on players the coaching staff can regulate the training intensity and amount of time on each exercise for each individual.

[5]http://www.prozonesports.com/service-opposition-analysis.html

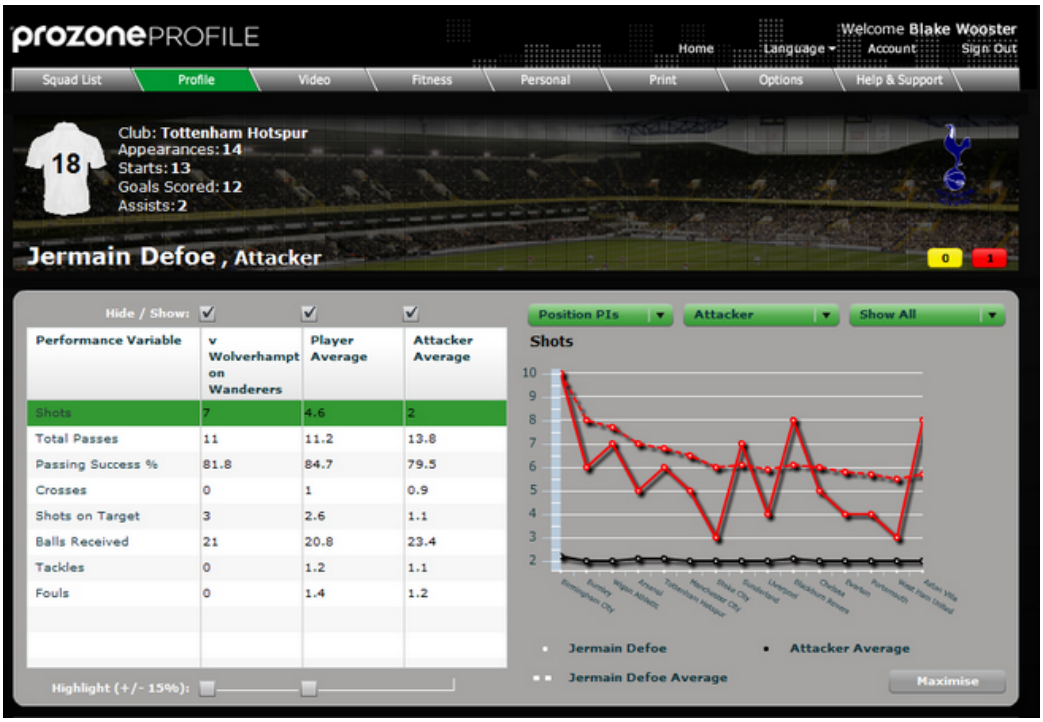

Figure 2.4: The Prozone software - individual player analysis gives you statistics of performance over time. Image from prozonesports.com

2.3.2 ZXY Sport Tracking System

ZXY provides you with a 3D graphic interface showed in figure 2.5. This interface lets you see the players action in real time by reading the data stream to reproduce actions by players. The data can be streamed in real time into the database as the match goes on. While watching you can produce timestamps of different events and produce manual input, which is time synchronized with the automatic data. Naturally, you can build your own software on top of the Sybase database. TIL in collaboration with University of Tromsø has made several systems to complement the ZXY software; Muithu[7] and Bagadus[10].

2.3.3 FourFourTwo

FourFourTwo is a monthly magazine about football. They also have a webpage that they update daily. Particular, they focus on match analytic with Opta providing them the data. All the analytics posted on their web page

Figure 2.5: The ZXY software - tracking of players gives you information of distance covered, average speed and max speed. You also get a heat map of the players movement on the field. Image from zxy.no

are created by using their own developed application Stats Zone. The application is available for everyone and its a popular among blogs writing about soccer analytic. Figure 2.6 shows a typical graphical illustration done with the Stats Zone application highlighting passes in to attacking third of the pitch.

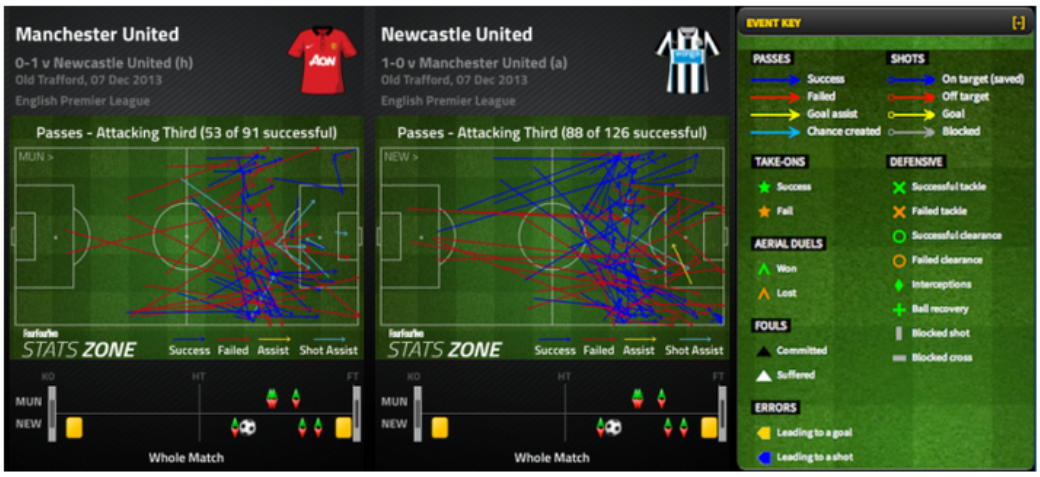

Figure 2.6: Illustration of all passes in to attacking third in the match Manchester United vs. Newcastle United. Taken from fourfourtwo.com

Chapter 3

Requirement Specification

This chapter outlines the requirement specification of the system and the process of gathering them. The process of gathering the requirements was done in collaboration with Tromsø Idrettslag (TIL).

3.1 Overview

The requirements evolved during the process of developing the system. Initially a requirement specification was designed from our perspective. We looked at the different analyzing systems out there and what was in use at Alfheim today. Many systems looks at a single match when analyzing like FourFourTwo's application. We are interested to see statistics over time to see if there are patterns of plays that is repeated. The quest of finding which players it is that creates goal-scoring chances is the driving force behind the system. It is easy to check who scores the goals and has the final pass, since these kind of statistics is easily found. Players playing in a more defensive role may have the same influence on the team-results as the top scorer.

Rather than going very wide providing all kind of analyses and statistics we narrowed it down to a very concrete system. The imagined system shall give you key players in the offensive play of a given opponent soccer team. Additionally you shall be able to see which areas of the pitch players are creating goal chances from. The system also needs a way of capturing data. This shall be an interface that enables you to store successful attacks for any match. We define key players as players that are often the breakthrough player in the build up of the attack by dribbles or passes. Figure 3.2 we have

identified involvements of a typical key player we want to capture.

3.2 Capture

A domain model for the captured data is crucial to set as early as possible in the process. A change to the model slows down the development process; captured data has to be re-captured and previous queries on data may fail due to missing fields. The domain model should reflect what we want to get out of the system. It sets the boundary's for which information we can pull from the system afterwards. When defining requirements TIL gave us a domain model they have used for a previous analytic project. The project presented a breakdown of all goals for Manchester United in the 2011/2012 season in Barclays Premier League. This data model shown in figure 3.1 is used as our foundation for our domain model.

Antall trekk	Målposisjon	Gjennombrudd	Gjennombruddspiller	Innlegg fra	Innlegg til	Plottet i figur	Touch
14	S2b	Pasning Bakrom	Ashley Young	I3	S4	Ja	2

Corner	Frispark	Skru	Innkast	Straffe	Angrep type	Angrep start
Nei	Nei	Nei	Nei	Nei	Etablert spill	Motstanders banehalvdel

Tid_mål	Omgang	Målscorer	Scoringsmulighet_prc	Målgivende	Antall_i_scoringsposi
13	1	Wayne Rooney	30	Ashley Young	2

Figure 3.1: A screen capture showing information TIL captured in a previous analytic project.

From this, we can define what the visioned system should capture from matches. The visioned system should capture from each match, every successful attack that leads to an attempt on goal. From each attack you capture where the attack started, every pass including from/to on the pitch, and what type of attack the attack can be categorized as. At last if there is a breaking point in the attack this should be captured. The breaking point of the attack should be stored with a breakthrough player and what type of breakthrough it was. Figure 3.2 illustrates the different breakthroughs we want to capture.

The visioned system also needs a data store. The data should be stored in a database that has a rich query language for being able to support the large range of queries on the data. Good support for aggregate functions is crucial. The data will consist of text and integers.

Additionally an interface for input will be required. This interface should ensure that the input data is correct. For example when defining what type

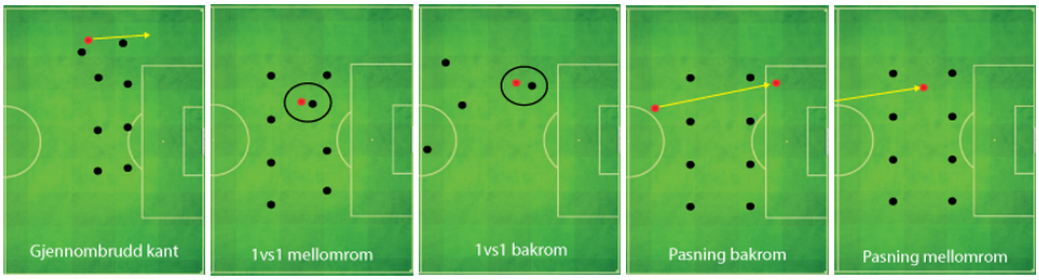

Figure 3.2: Illustrations of different breakthroughs we want to capture. Each situation can be seen as the breaking point of the attack

of attack the attack is, only the predefined options should be valid as input.

Capturing every pass in successful attacks requires a position system. Here we suggest a more coarse grained dividing of the pitch than a typical X,Y coordinate, like Opta and Prozone use. The process of defining how to divide the pitch into zones took several rounds of discussion leading to several types. These are shown in figure 3.4.

3.3 Present

The presentation of the data is an important aspect of the system. This will be where the end-users will spend their time. The presentation of data needs to be as simple as possible to understand. The coaching staff is no technical experts and the system is aimed for them to use. Therefor, the system will need to present statistics and other valuable information in a clean and understandable way.

In the end it is the 11 players the coach selects that perform all the actions, but the coach sets the style of play and boundaries for players. The goal is to give the coach the opportunity to use the system, using both illustrations and statistics, so he can better reach out to his players with his ideas. The better a coach can sell his ideas to the players the more they will believe in the philosophy, style of play and follow the game plan in games.

We purpose a web interface here, as it is accessible from many devices as long as you have an Internet connection and an up to date web browser.

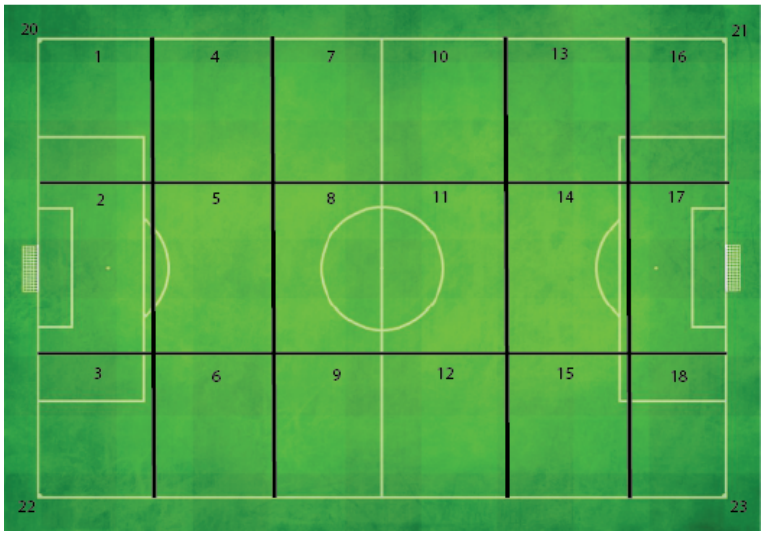

Figure 3.3: Dividing of pitch - the first suggestion had 18 zones

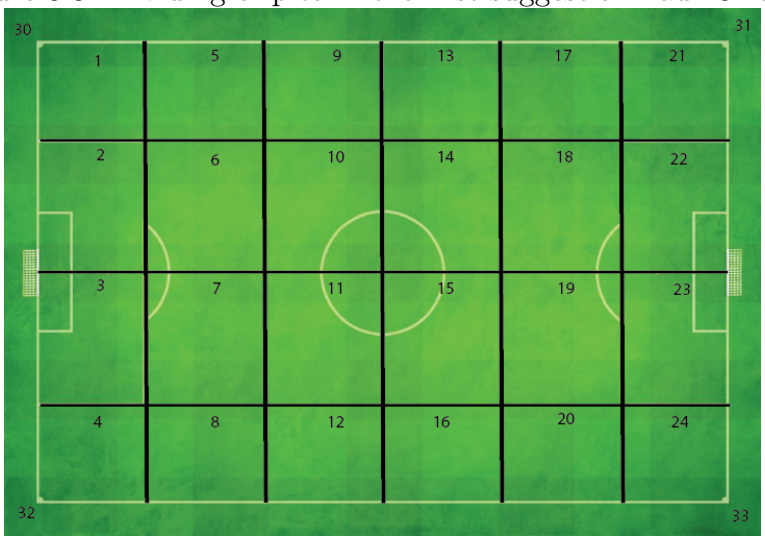

Figure 3.4: Dividing of pitch - the second suggestion has more zones, counting 24 zones

3.4 Non-functional requirements

The system need to be fast for the end user to get an enjoyable experience. Usability and response time when navigating the User Interface (UI) is linked, having a slow system decreases the satisfaction of the user.

3.5 Summary

To summarize, we need a storage for persisting the data and run queries on, a back-end for transforming client requests to database operations, and an interface for capturing and presenting analytic information. Figure 3.5 shows the conceptual architecture.

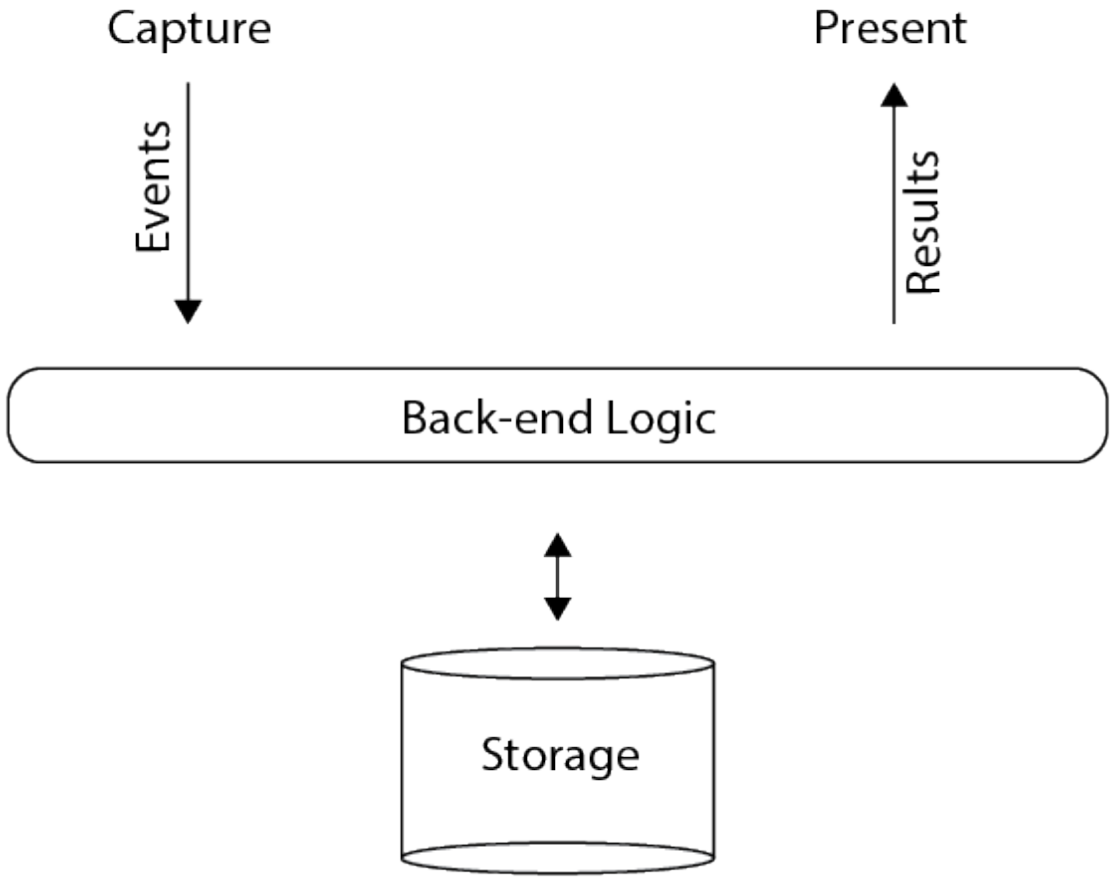

Figure 3.5: Conceptual architecture.

Chapter 4

Soccer Analytic toolkit (SAT)

4.1 System Architecture

The system architecture can be layered into three layers; client (interfaces), back-end and database. The control flows from the clients requesting a page or inserting data, to the back-end, who communicates with the storage. From the storage, the execution cycle is reversed. The storage will execute what its been asked to do by the back-end and return the result. The back-end then again returns the result to the client.

4.1.1 Interfaces (1)

The Soccer Analytic tool has one user interface - the web browser interface. Both the capturing and the analytic interfaces can be reached from this single web browser interface running on the same domain. All interfaces are created on the client with client-side scripting using JavaScript. The client will get data from the back-end and construct the interfaces dynamically, typical for Single Page Application's[12].

4.1.2 Back-end (2)

The back-end is the middle layer between the client and the storage. Its main task is to serve static files to the clients, handle data insertions or

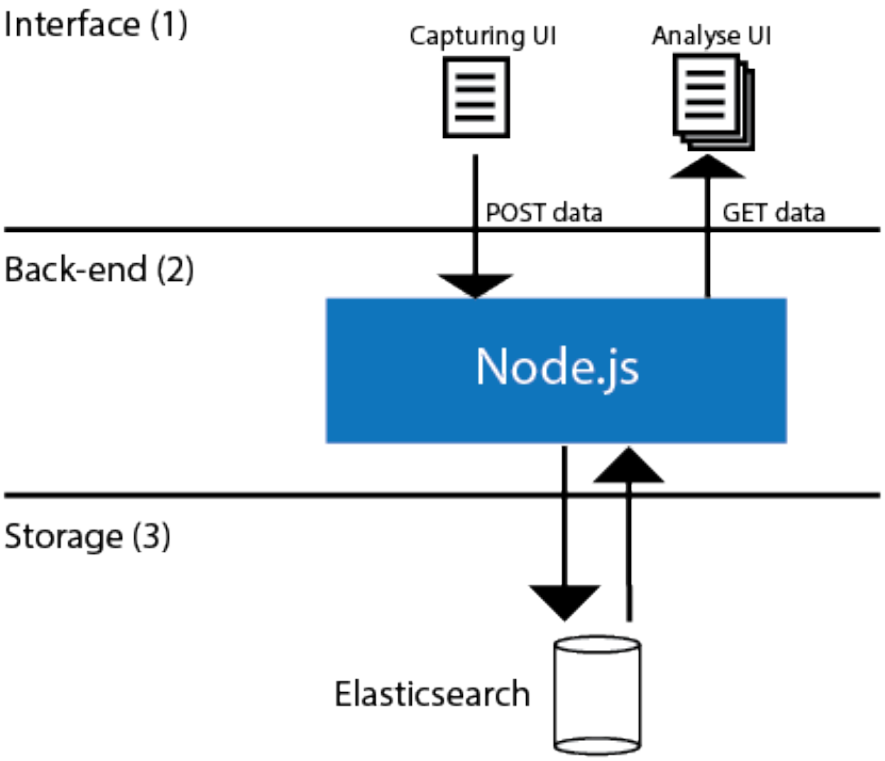

Figure 4.1: Overall architecture of the system

handling web request by mapping them to database operations. New data insertions are possible inserted into several database indexes. The back-end will then ensure that all indexes are updated before returning success to the client.

4.1.3 Storage (3)

The storage layers task is to persist data and handle search queries on the data. It consists of several indexes that each stores a part of the domain model. The storage will get requests over Hypertext Transfer Protocol (HTTP), examine and execute them, before returning a response over the HTTP connection.

4.1.4 Domain model

The domain model is based around matches. All attacks are wrapped into a match root document as subdocuments of the match document. Inside each attack, all passes together with other information related to an attack is. This gives the end-users an easy way of understanding how all the data is related together. Below is a complete example of how it all is structured. The number of attacks and passes is stripped down to one in the example.

```
{
    "hometeam" : "Tromso",
    "awayteam" : "Rosenborg",
    "score" : "1-0",
    "date" : '2013-15-09',
    "attacks": [
        {
            "time": 4,
            "touch" : 1,
            "team" : "Tromso",
            "breakthrough" : "None",
            "breakthroughPlayer" : "None",
            "typeOfAttack" : "Dodball",
            "attackStart" : {
                "pos" : 17,
                "typeAction" : "Frispark",
                "player" : 403,
            },
            "passes": [
                {
                    "fromPlayer": 403,
                    "toPlayer": 393,
                    "fromPos": 17,
                    "toPos": 23,
                    "action": "CROSS"
                }
            ],
            "finish" : {
                "player": 393,
                "pos": 23,
                "action": "SHOTMISS"
            }
```

},
}

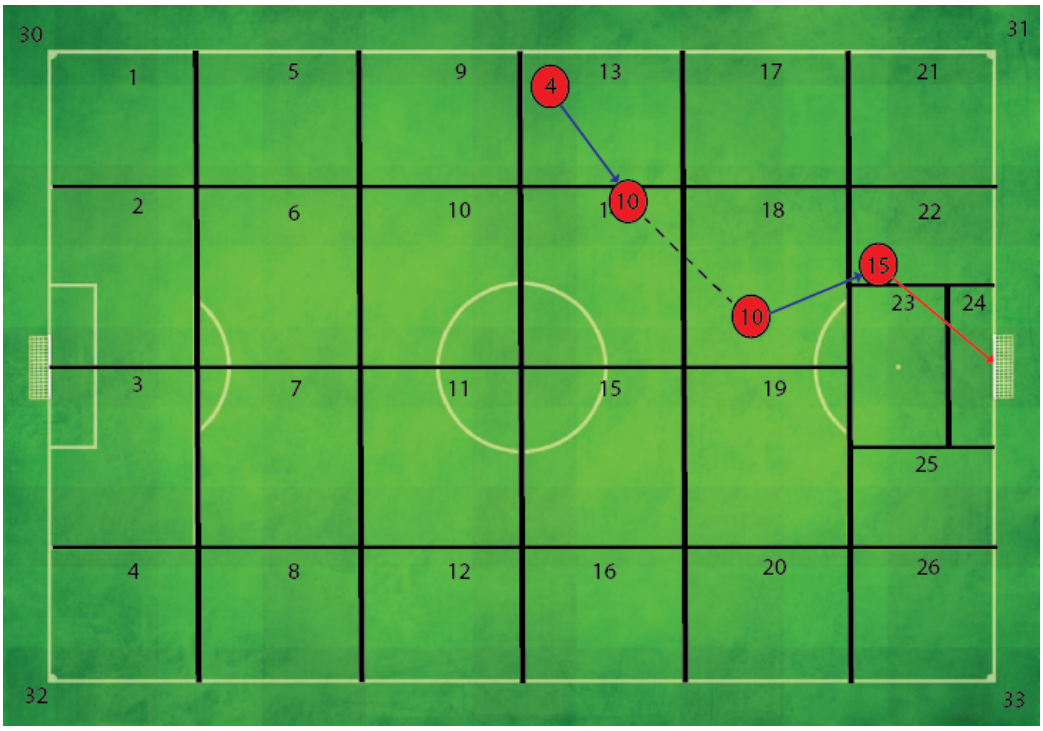

Figure 4.2: The final dividing of the pitch attacking from left to right. More zones have been added to the penalty box area than the initially model.

Figure 4.2 shows the final version of the pitch dividing with a illustration of how the dividing is used when storing attacks. Player 4 plays to player 10 from zone 13 to zone 14. Player 10 transports the ball until he passes to player 15 from zone 18 to 22. Player 15 tries a finish from zone 22 inside the penalty area. The reason for going for more zones in the penalty area was a specific request by Tromsø Idrettslag (TIL) to be able to see more specific where attacks are finished from.

Software Stack	
Web server	Node.js
Database	Elasticsearch
Web Interface	HTML5, CSS3
Client Side Technology	Backbone, Bootstrap, jQuery, Mustache, Highcharts, Lightbox, async

Table 4.1: Software stack

4.2 Implementation details

4.2.1 Storage

The data storage is an Elasticsearch[1] database. Elasticsearch is document oriented, schema less and works well with JavaScript Object Notation (JSON)[2]. As our server is built on server side JavaScript, working with JSON is easy. JSON-objects is sent to the Elasticsearch, and will be mapped to fields and values, and made available for search in real time. Elasticsearch takes advantages of embedded documents meaning we can store related data together. An attack is usually made up of several passes and can be stored as embedded documents wrapped in the attack document. Then all passes can be retrieved in one query when fetching an attack. Similar, retrieving a match will get all attacks and their corresponding passes in one query.

One of the main reasons for using Elasticsearch is its search capabilities. In the starting phase of the project MongoDB[3]was the storage engine. However, as some aggregation queries were hard to figure out how to do, a change to Elasticsearch was made. It should be noted that MongoDB supports map reduce operations. With some extra work the queries causing problems could possible have been done with MongoDB. However, with Elasticsearch you can in a single, simple to write query get counted how many passes all players for a team has played and received, the number of times all players has been the breakthrough-player in an attack, sum type of attacks, count the most used zones for passing and finishing in the attacks and so on. This makes it very easy and efficient to do queries for analyses on teams and players.

Another feature of Elasticsearch is how easy it is to scale it by adding new nodes to your cluster. It is built to scale horizontally out of the box. Elasticsearch uses a sharding technique to spread data across the cluster. Basically, it breaks up the data into smaller chunks spreading it across the cluster of

[1]http://www.elasticsearch.org/

machines to achieve scalability and performance. The configuration setup is highly adjustable letting you specify number of shards and replicas the storage shall keep. Adding a new machine to the cluster will automatically start a reorganizing process of the data to take advantage of the extra hardware. This make it suitable as our storage if we wanted to expand the project by adding more data and having more end users.

4.2.1.1 Indexes

Indexes are much like tables in a relational database in the way that they are a container for data. An index stores documents, which is a bunch of key/value pairs, like JSON. You can let Elasticsearch automatic analyze the field data or you can use mappings. For supporting querying on players and other fields where the value is more than one word, you have to tell Elasticsearch that it is a multi field. For example, searching for player names, which is made up of two words, when the field is not set as multi field, will give out two results and not one, as you would expect.

In our project we have 5 different indexes.

- *Team index*: Holds all the teams.
- *Player index*: Holds all players for every team.
- *Match index*: Holds all data from every match, including all attacks for each match.
- *Attack index*: Holds all attacks in every match.
- *Pass index*: Holds all passes in every attack.

Listing 4.1.4 shows an example of data stored from a match. As may be noted there is data redundancy as some indexes stores the same information. One can argue that storage has become so cheap and if you can use a little bit extra space to gain performance you would do it. In this case it was done to be able to fully support aggregation functions on subdocuments explained in more details in section 4.2.2

[3]http://www.json.org/
[3]http://www.mongodb.org/

4.2.2 Facets

Doing searches in Elasticsearch returns documents that matches your query. Facets provide an ability to do aggregation functions on the result-documents from your query. In the system, this feature is used a lot. An example is a query on all attack documents matching a team name. After fetching every document, aggregation functions will run on the resulting set of documents. This includes counting the number of times a player has been the sender and receiver of a pass, number of times he has been the breakthrough player, sum the type of attacks to mention a few.

Elasticsearch will return the whole root document when you do a match query on a field in a subdocument. Since attacks for both teams are stored inside the same match document, we would get both teams attacks when doing a match query on a attack subdocument. This would again lead to aggregation functions running on both teams attack, something that would not be correct. Therefor, we have some data redundancy in our database by having multiple indexes.

Another solution to avoid data redundancy would be to store attacks for a team in a own match document. This would lead to a little more complex query when fetching matches, but save us from storing duplicated attacks and passes. If this were to be implemented again, it would most likely have been the solution.

4.2.3 Back-end

4.2.3.1 Overview

The back-end is the middleware between the clients and the data layer and is written in Node.js[14] It exposes a Representational state transfer (REST)[4] interface over HTTP shown in figue 4.2 for the client to communicate. A request coming in is transformed to a database query based on the resource (URL) it tries to access. Node.js is a packaged compilation of Googles JavaScript engine[5] engine. Its a relatively new (being released in 2009) and unproven platform, but has gained a lot of hype in the computer science community for its lightweight and efficient model. This comes from the even-driven and non-blocking I/O model. Per default, an instance of node

[4]http://www.ibm.com/developerworks/webservices/library/ws-restful/
[5]https://code.google.com/p/v8/

runs in a single thread and does not utilize other CPU cores. When writing a web server with Node.js, you need to avoid long, blocking computations as this will block the node process for handling new incoming requests. Our back-end uses non-blocking I/O calls when accessing the database to avoid this issue.

The back-end takes use of several node packages[6], including the Express framework, which is a web framework.

4.2.3.2 Routing

The web server code is structured up in modules. For example requests on the URL /players is routed to the Player module for further handling. Similar, you have an attack module, pass module, team module, player module and a match module. A very often used URL is /team/:name. A HTTP GET on this URL will be routed to the team module where a query for information about the specified team is run. On answer from the database, the result is transformed before returning it to the client.

Similar, if the client sends new data for a match the server will insert the data into the appropriate indexes. The server will respond will HTTP status code 201 if all goes well or 400 on an error. The server uses HTTP code actively to tell the client the result of a request. For all HTTP POST requests the server will send status code 201, meaning that a new resource is created. For HTTP GET requests the server responds as normal with status code 200, if all went well.

No URL route uses HTTP PUT and DELETE methods. These methods could have been used for deleting or updating attacks or passes. Typically, an operator will do a mistake while capturing new attacks, and then these HTTP methods would be naturally to use to update or delete data.

In principle, since the data input is generated in the web browser (with JavaScript), it could have been inserted right away into the database because of Elasticsearchs Create Read Update Delete (CRUD) API[7]. Having the server API we can hide details from the client as combining multiple queries, joining and cleaning of data. Normally, you validation of the data at the back-end is done before inserting into to the database. The client also needs to get the client code from somewhere. Therefor, having a web server was the chosen way to go.

[6] https://npmjs.org/

[7] http://www.elasticsearch.org/guide/en/elasticsearch/reference/current/docs.html

4.2.3.3 API

The Application Programming Interface (API) of the web server is listed in figure 4.2. As mentioned the API follows the basic REST principles using the URL as a resource identifier and HTTP methods like GET and POST to specify actions to be taken on the resource.

Web server API	
GET /matches	Get all matches
GET /match/:id	Get specific match
POST /match	Post new match
GET /teams	Get all teams
GET /team/:name	Get team statistics
GET /team/:name/finalthird	Get passes into final third of the pitch
POST /team	Post new team
GET /player/:id	Get player statistics
GET /player/:id/breakthroughs	Get breakthroughs for player
GET /player/:id/finalthird	Get passes into final third of the pitch
POST /player	Post new player
POST /attack	Post new attack
POST /pass	Post new pass

Table 4.2: Overview of the web servers API

4.2.4 Client and interfaces

The front end is a Single Page Application (SPA) using Backbone.js[8]as under-supporting library. Having a SPA model means that not every code is necessary loaded at once (HyperText Markup Language (HTML), Cascaading Style Sheets (CSS) and JavaScript), but when needed. Also, the whole page does not reload when users navigate around, only parts of it will be updated. This is all possible because of Asynchronous JavaScript and XML (AJAX), a way for JavaScript running in a browser to make HTTP requests to back-end web servers. Its asynchronously, meaning that the web page is still responsive and navigable during the request[8].

Backbone uses a Model View Presenter (MVP) model to structure the code.

With Backbone your views will update automatic when data changes. You use Backbones models and presenters (called views in the documentation of Backbone) by letting your own models and presenters inherit Backbones basic classes. Figure 4.3 shows how the overall architecture of the front-end. In the following sections the architecture of the client and how different concepts in Backbone is used will be described.

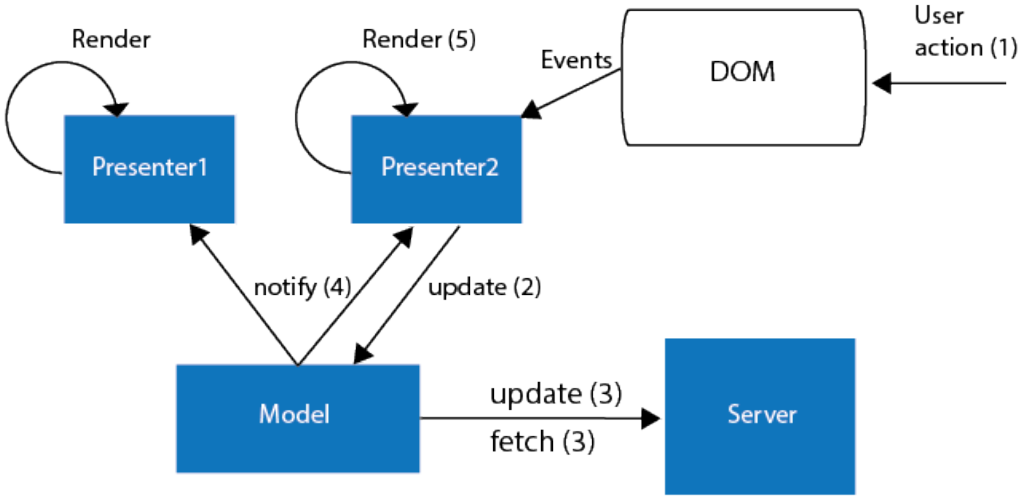

Figure 4.3: Architecture of the client side. Numeration is used in the text to reference the figure

4.2.4.1 Models

In Backbone you encapsulate data and do communication with the back-end with objects called models. A model has mainly two responsibilities; whenever an update on a models data occurs the model notifies the presenters that have subscribed for update events for that particular model (4). The second is that models are responsible for AJAX communication with the back-end (3). An example is when a user registers a new attack for a match. He fills out a form and press the submit button (1). Then a new attack model containing the data type in the form is created. Calling save on the model will send an AJAX post request to the server with the models data in the HTTP body (3).

[8]http://backbonejs.org/

Similar to an attack model, we have player models that handles everything around a player. When a user navigate to a players profile, the model will fetch statistics from the back-end (3) and notify the presenter that the data is ready (4), and the HTML will be rendered in the web browser.

There is also a match model for fetching and registration of matches, team model for viewing statistics, and a pass model for saving passes. They work it the same way as the models described above using AJAX to communicate with the back-end and notification presenters on data changes.

4.2.4.2 Collections

Collections are a set of models. It has almost the same functionality as a model. You can bind functions to happen on events for any model in the collection. On the client there is two places where collections are used; players and teams. Naturally, players contain many player models and teams collections contain many team models.

4.2.4.3 Presenters

Presenters are the glue between the Backbone models and the view (web page). Presenters can bind own functions to respond to models events. For example on data change event from a model the presenter will call its render function and the User Interface (UI) will be updated (4). Each presenter has a own HTML div tag which it inserts HTML to. Including to subscribing to events on models, the presenter can subscribe for view events that happens in the Document Object Model (DOM), events that the user triggers (1). Following up the example in the previous section, on an attack registration. When a user press the submit button the presenter will be notified. He will create a model for the attack and call the save method on the instance object.

On initialization of a presenter object it is initialized with a model or a collection depending on the view it should render. After the model/collection has fetched its data the presenters render function will be called. This is where the data is inserted into the HTML template (5) explained in more details in the next sections.

4.2.4.4 Views

For an analytic toolkit to be useful a good presentation is critical. Here several helper libraries are used to present the data. Highcharts.js[9]is a JavaScript library for illustrating statistics. A query on team generates a lot of statistics and rather than listing them up they are presented using charts. Using charts gives us the advantage of displaying several numbers for each player by plotting it in the same graph. In figure 4.4 the number of times a player has been involved in all attacks, the number of passes into the final third of the pitch and the number of times a player has been the breakthrough-player is shown.

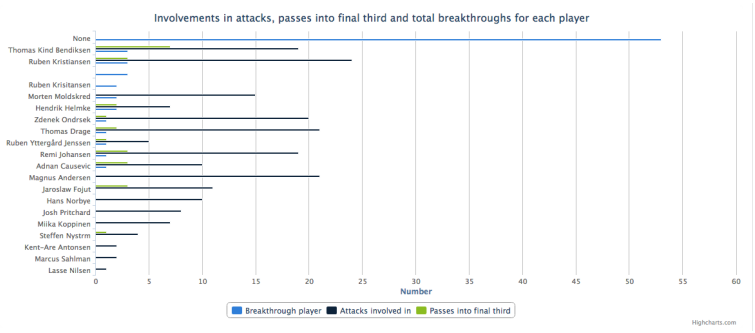

Figure 4.4: Shows how statistic is illustrated on the client by using Highcharts.js.

To display statistics as where attacks have been finished from we are using the HTML canvas element. It lets you draw graphics on the fly in the web page. In this system it is used to create an element that symbols the different zones in our domain model by drawing a soccer pitch with the all the zones plotted. The team model will fetch data from the back-end containing numbers for all zones. This is then plotted into the respective zones on the pitch as figure 4.5 is showing.

Backbone comes with a library Underscore.js[10]that makes creating HTML pages with dynamic content easy. When you are rendering new content on the site you can insert data retried from a model dynamically into the HTML. This is the presenters responsibility (5). In the example below the input is a an array of objects where each element in the array contains a key value pair 'name' : value. The HTML output of this will be a list of all player names in the array.

[9]http://www.highcharts.com/

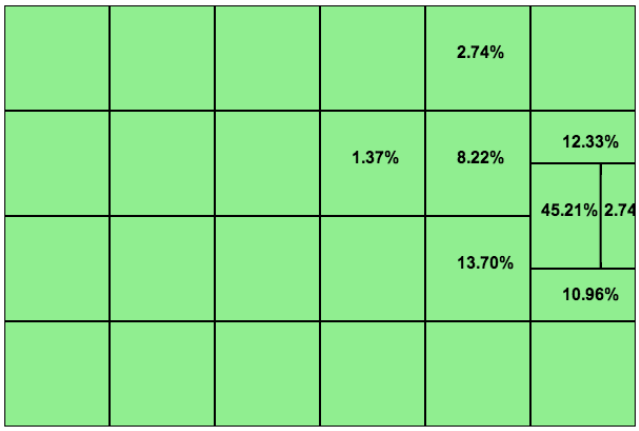

Figure 4.5: Illustrates which zones TIL has finished their attacks from in percent.

```
{{#players}}
        <li>{{name}}</li>
{{/players}}
```

4.2.4.5 Router

A component not mentioned before is the router. The router is the glue that binds all the other Backbone modules together. It handles the navigation between pages in the application. When users navigate on the page by clicking on links or buttons in a traditional web page the back-end serves a new HTML page. Here, a router module handles this click event. The router model examines the URL request and routes the request to the presenter responsible for that specific route. This is mapped inside the router. The presenter will then call fetch functions on the model to get data from the back-end and render the HTML to its assigned DIV.

The header on the page is static and will only be rendered once when the user first visits the web page.

[10]http://underscorejs.org/

4.2.5 Building the database, players and teams

Finding squads in a useful format like eXtensible Markup Language (XML) or JSON was harder than expected. On the Norwegian football alliance's website you could download the squads for the current season, but only in PDF format. Current squads is fetched from altomfotball.no, a website by the Norwegian broadcasting company TV2. The fetching process is an own python script meant to run only once to set up the database. For each team the script basically reads the HTML document with all players listed, parse out players name, and sends in to the web server.

4.2.6 Security

Security is not taken into concern in the system. This means anyone getting into the page can post new match data and add attacks. This could have been fixed by requiring a login before getting access to the site.

Chapter 5

Demo

5.1 Interfaces

5.1.1 Mockup

Figure 5.1 shows a mockup of the team analysis page that was created before starting developing. There are two main sections in the mockup: team statistics and key players. This mockup was used as the base for which type of statistics the team analytic page should give and was worked out in collaboration with Tromsø Idrettslag (TIL).

In the team statistics section, types of attack (counter attack, long attack etc.) is illustrated in a graph, there is an overview of different breakthroughs, basic statistics like key players, number of attacks, average possession is listed, and a plotting of which zones attacks are started from.

In the other section, key players and their statistic are listed. You have an overview of where on the pitch the player is involved in attacks, plotting key passes he has played and where on the pitch his ball recovery's are.

5.1.2 Implemented interfaces

The whole web page follows a theme throughout the pages. This theme is the standard theme in the Cascaading Style Sheets (CSS) and JavaScript library Bootstrap[1]. Bootstrap makes the website by default responsive. This

[1] http://getbootstrap.com/

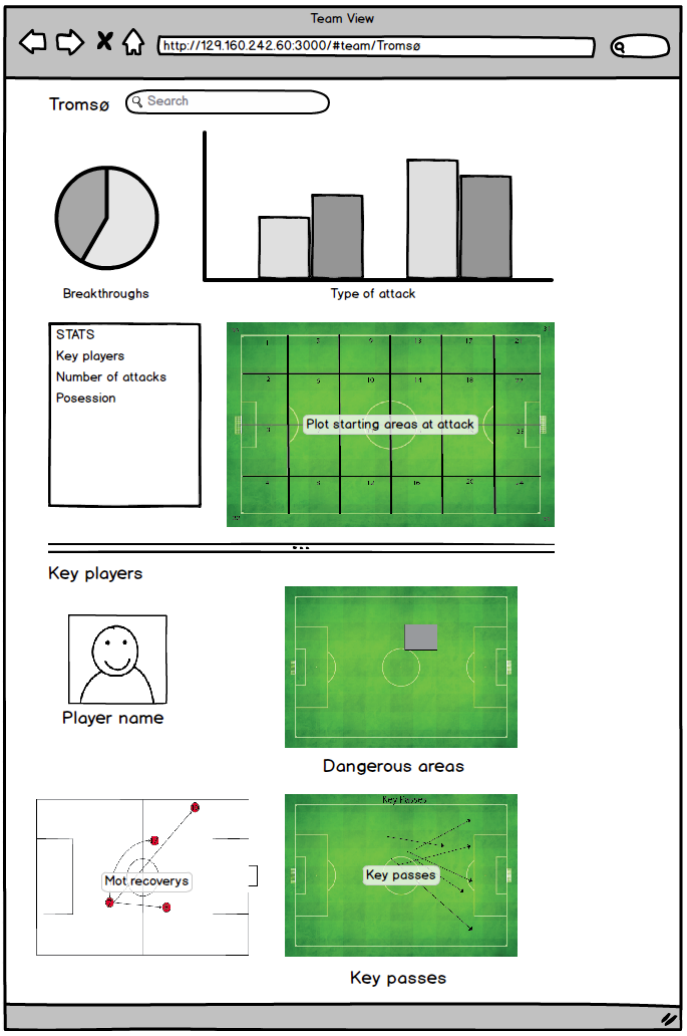

Figure 5.1: A mockup of the main analytic page

means the content on the site is automatically re-sized out from your browser window size.

5.1.3 Home page

The first page you are prompted with is the listing of all matches registered in the database as figure 5.2. A click on match gives you details about that particular match.

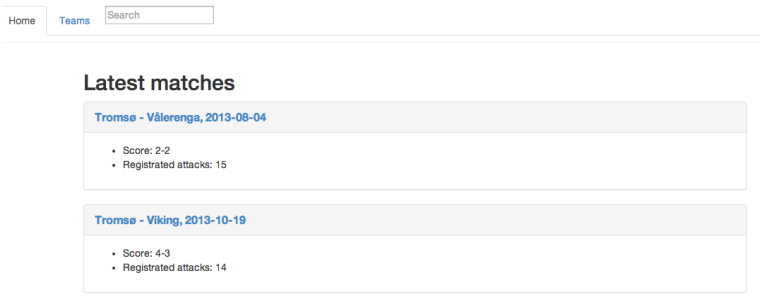

Figure 5.2: All matches registrated in the database are listed on this page. Image is cropped not listing all matches.

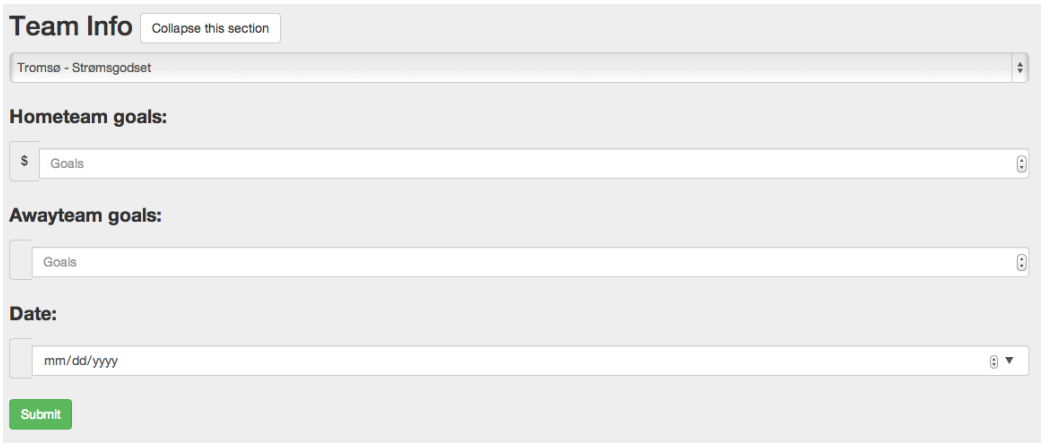

Figure 5.3: Interface for registering a match

5.1.4 New match

Clicking New match sends you to match register interface shown in figure 5.3. The users have to register the match he wants to capture data before anything else.

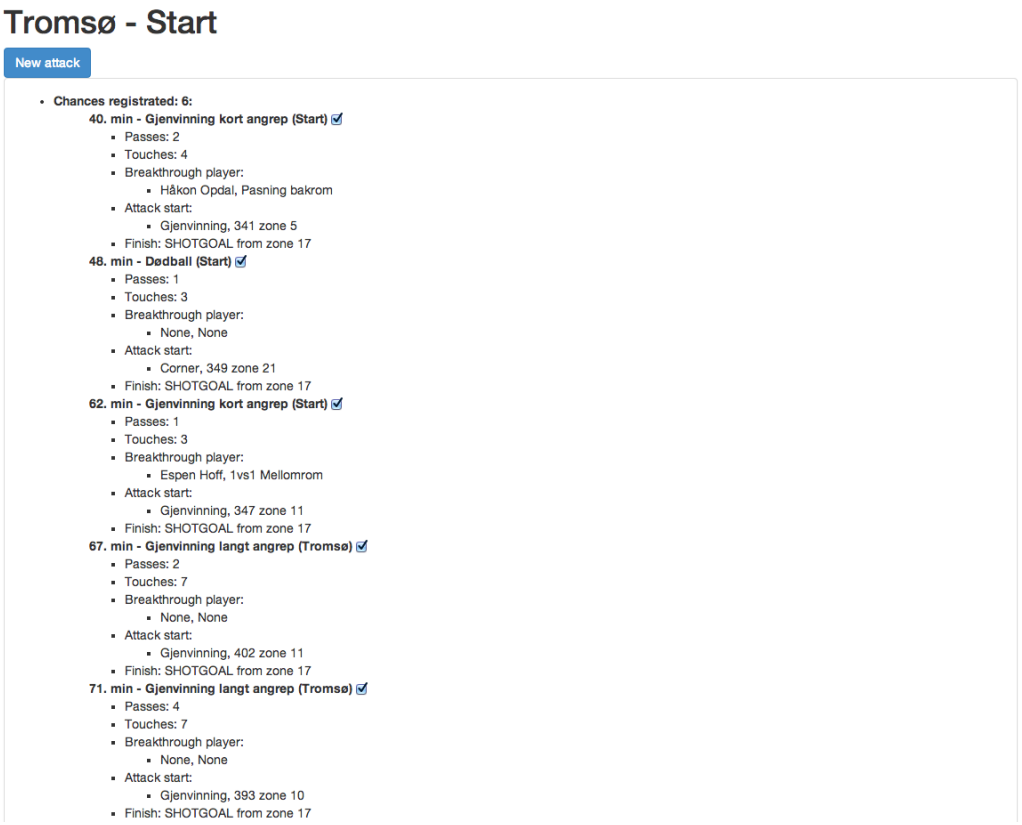

Figure 5.4: Interface listing up all attacks for a match.

5.1.5 Match view

Clicking on a match gives you overview of all attacks registered for that particular game shown in figure 5.4. This view is only meant for quality checking the data.

5.1.6 New attack

From the match page you can add new attack attempts. Figure 5.5 shows the form. Attack start, attack end, breakthrough player, time and team needs to be filled out. Extra passes in the attack are added by pressing new pass. This will add a new pass to the form. Passes can be deleted by clicking the red remove pass button.

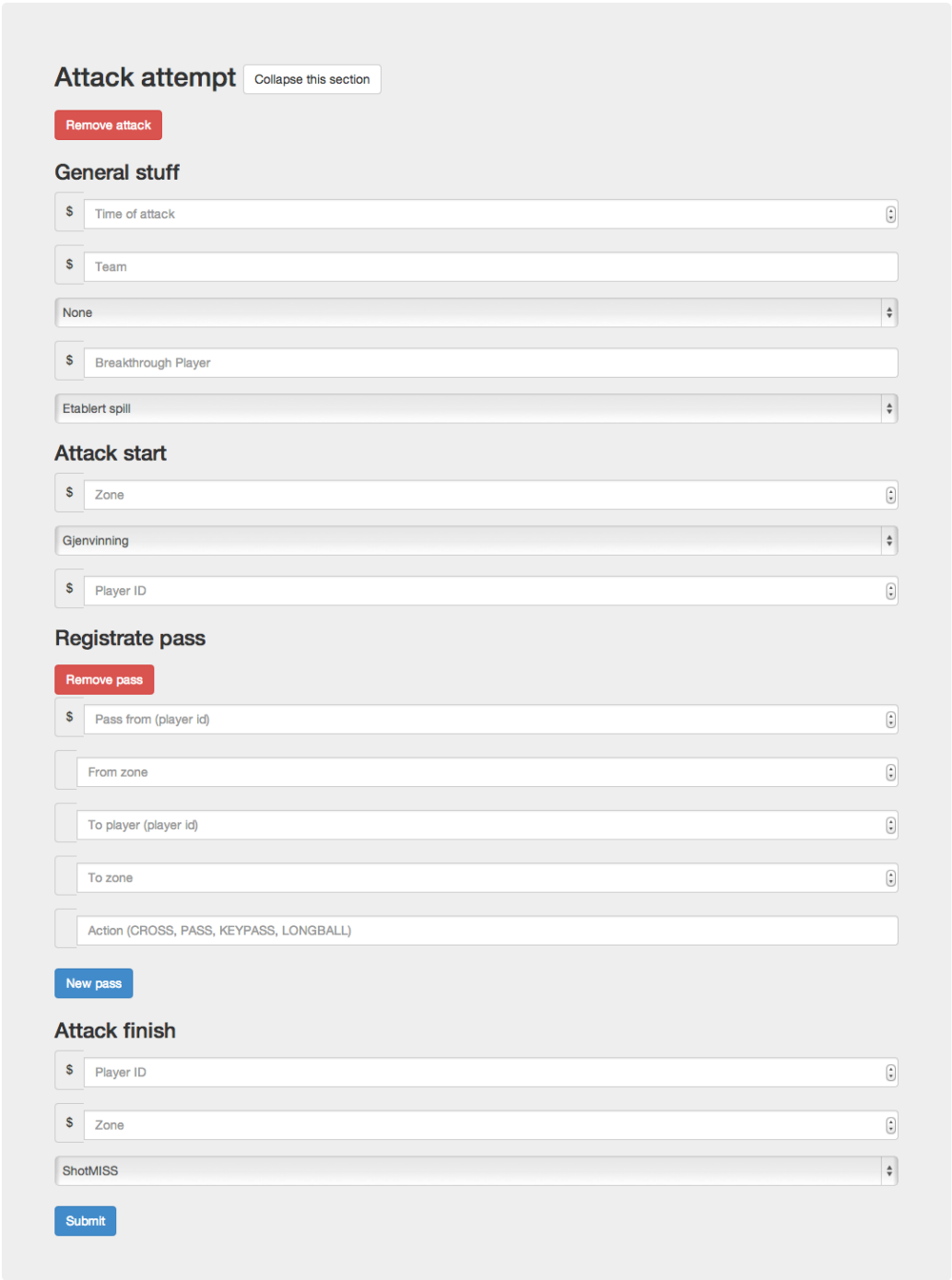

Figure 5.5: Interface for register an attack.

5.1.7 Teams view

Then you have the team selection page shown in figure 5.6. You navigate to this by pressing the tab at the top of the page. This is a simple layout listing all the teams in the Norwegian premier league. From here you select the team you want to analyze.

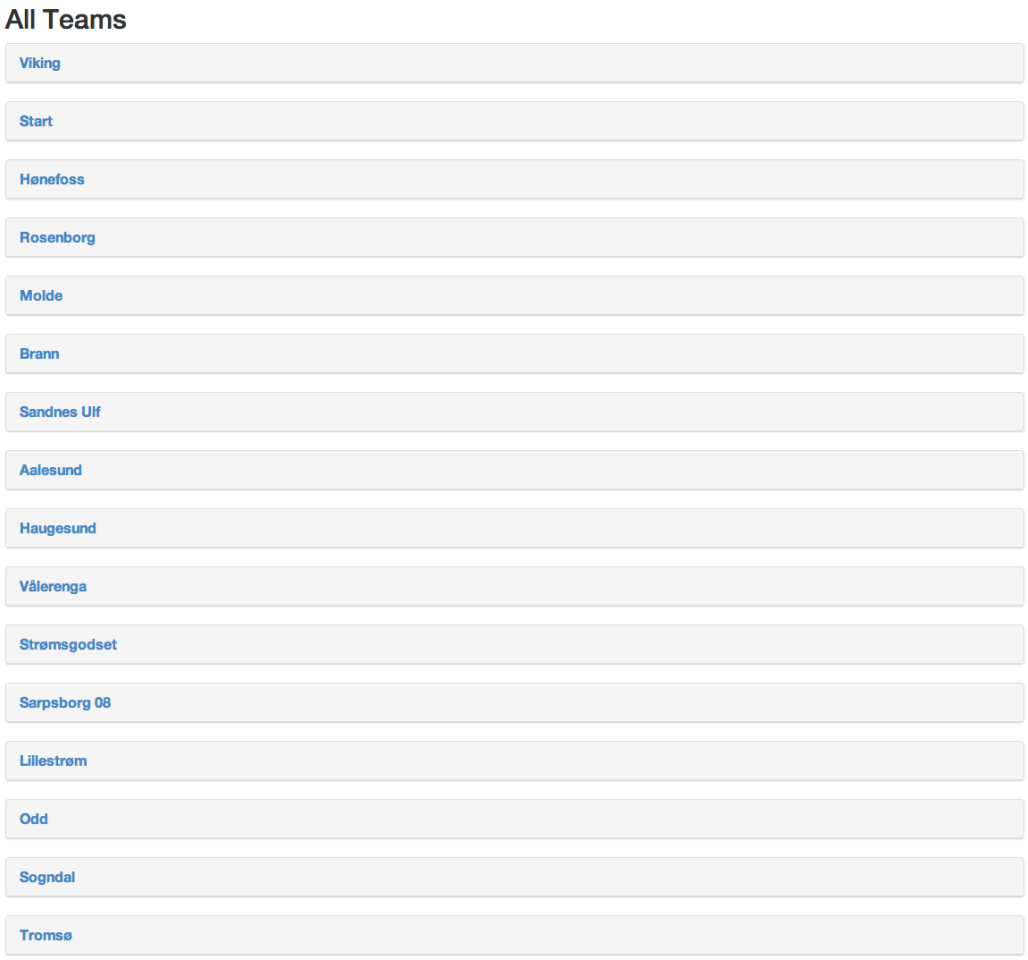

Figure 5.6: Interface listing all teams.

5.1.8 Team view

Then there is the main view used for analyzing a team, showed in figure 5.7, figure 5.8 and figure 5.9. The page design is not exactly the same as

the mockup. This comes from a various things. A description of different breakthroughs has been added to enlighten users of the system. Users of the system may or may not have been involved in the process of capturing the data and therefor-extra information is needed to clarify concepts. In the mockup key players where highlighted. In the final view various statistics is presented to the user and he can then click on players he find interesting to know more about as shown in figure 5.10. The whole page is divided into 4 sections; key aspects, offensive play, defensive play and players.

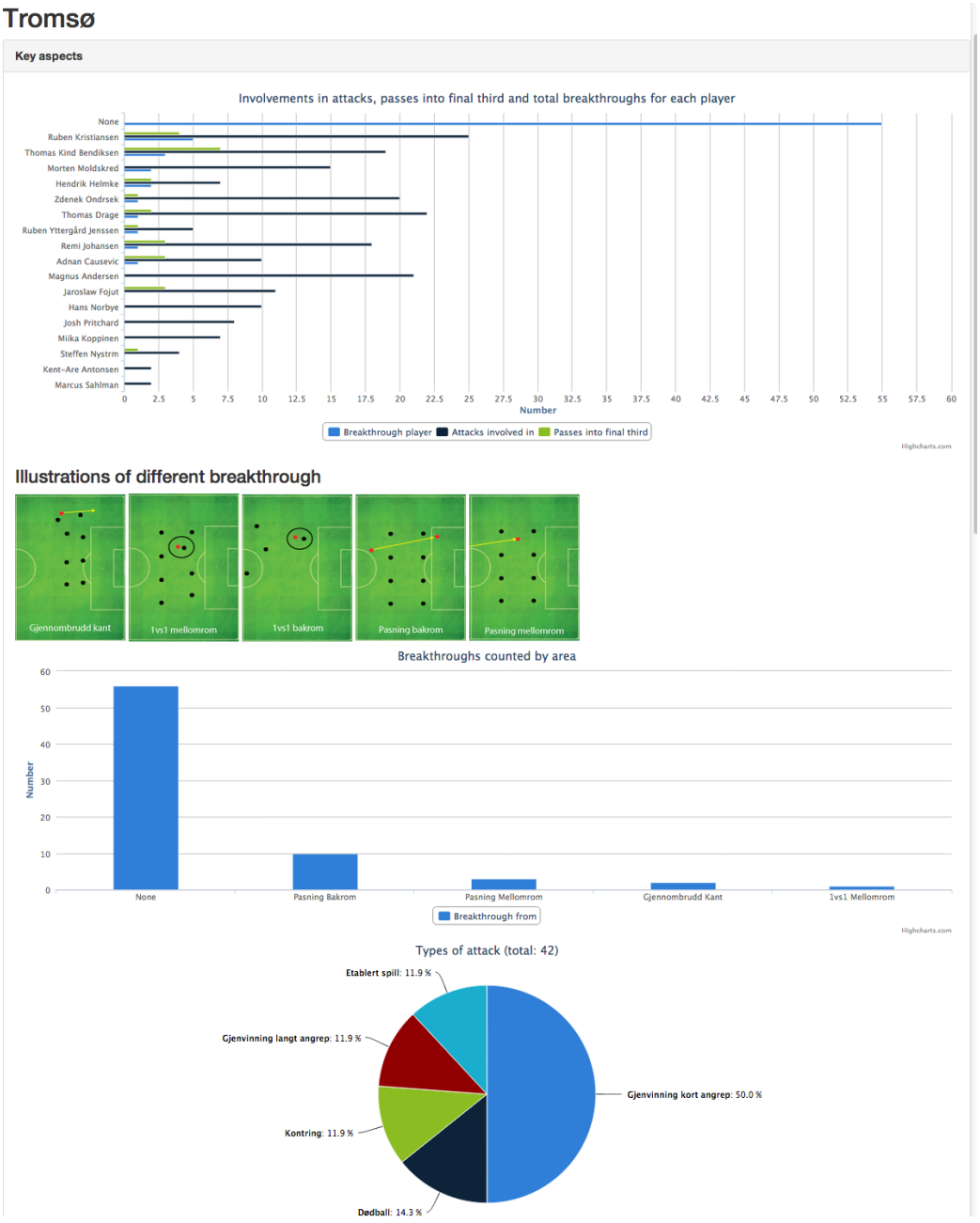

Figure 5.7: Main interface for information about opponents - key aspects.

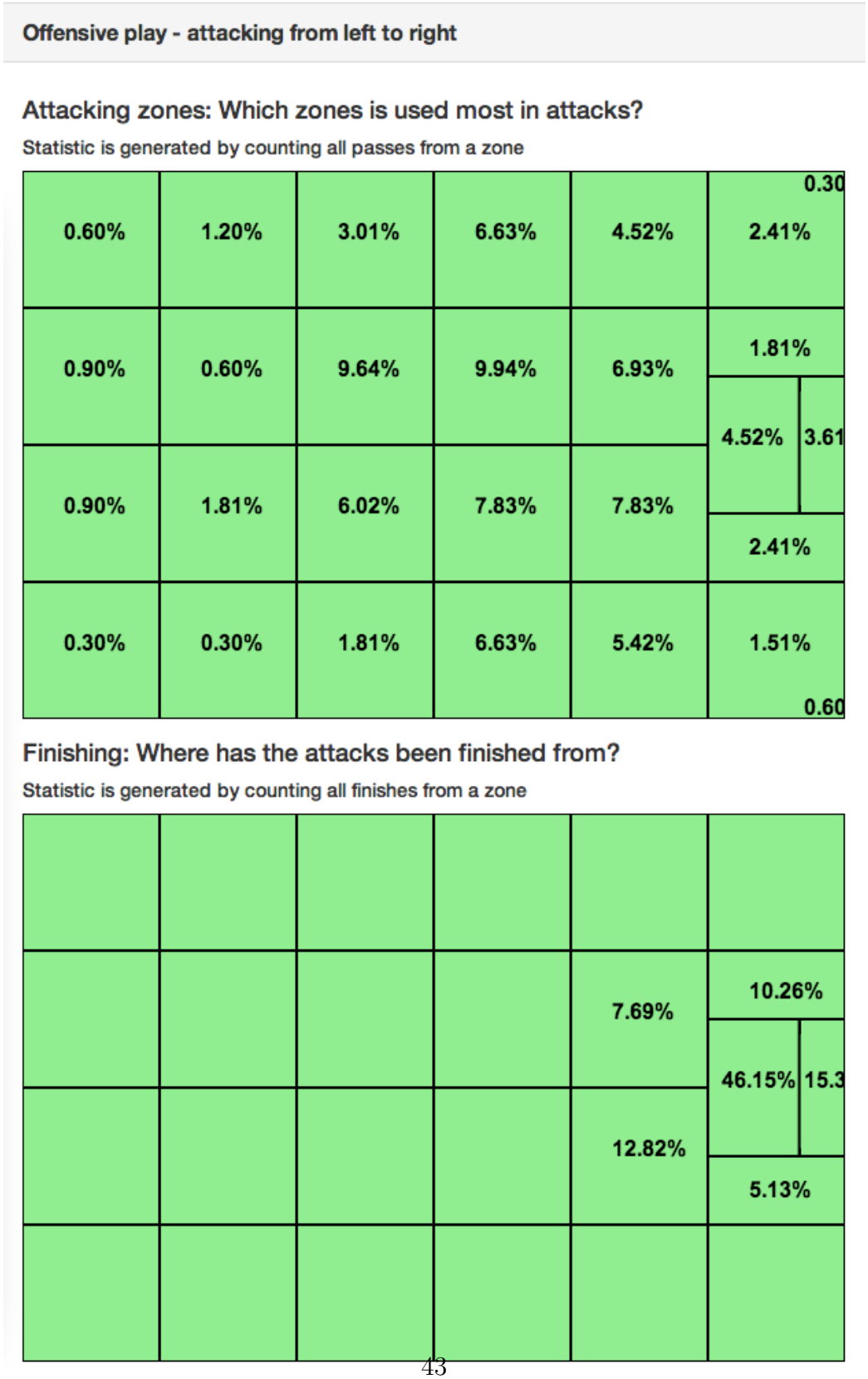

Figure 5.8: Main interface for information about opponents - offensive play.

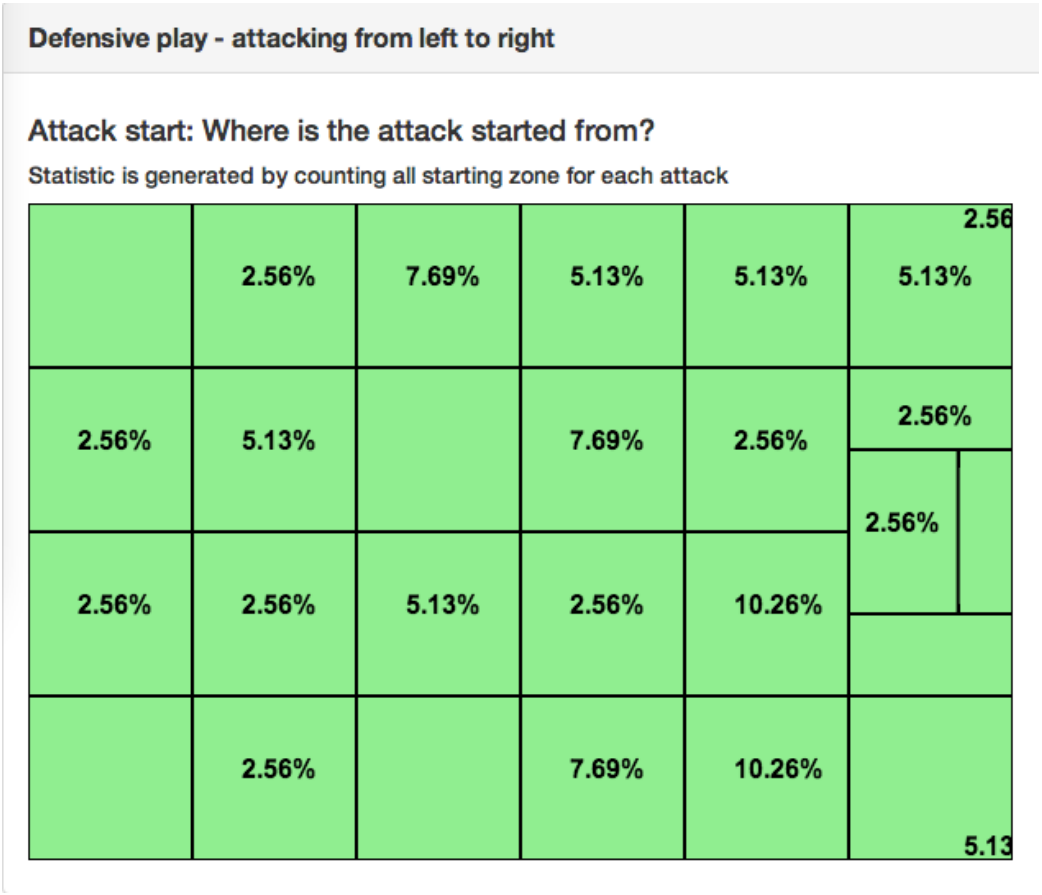

Figure 5.9: Main interface for information about opponents - defensive play.

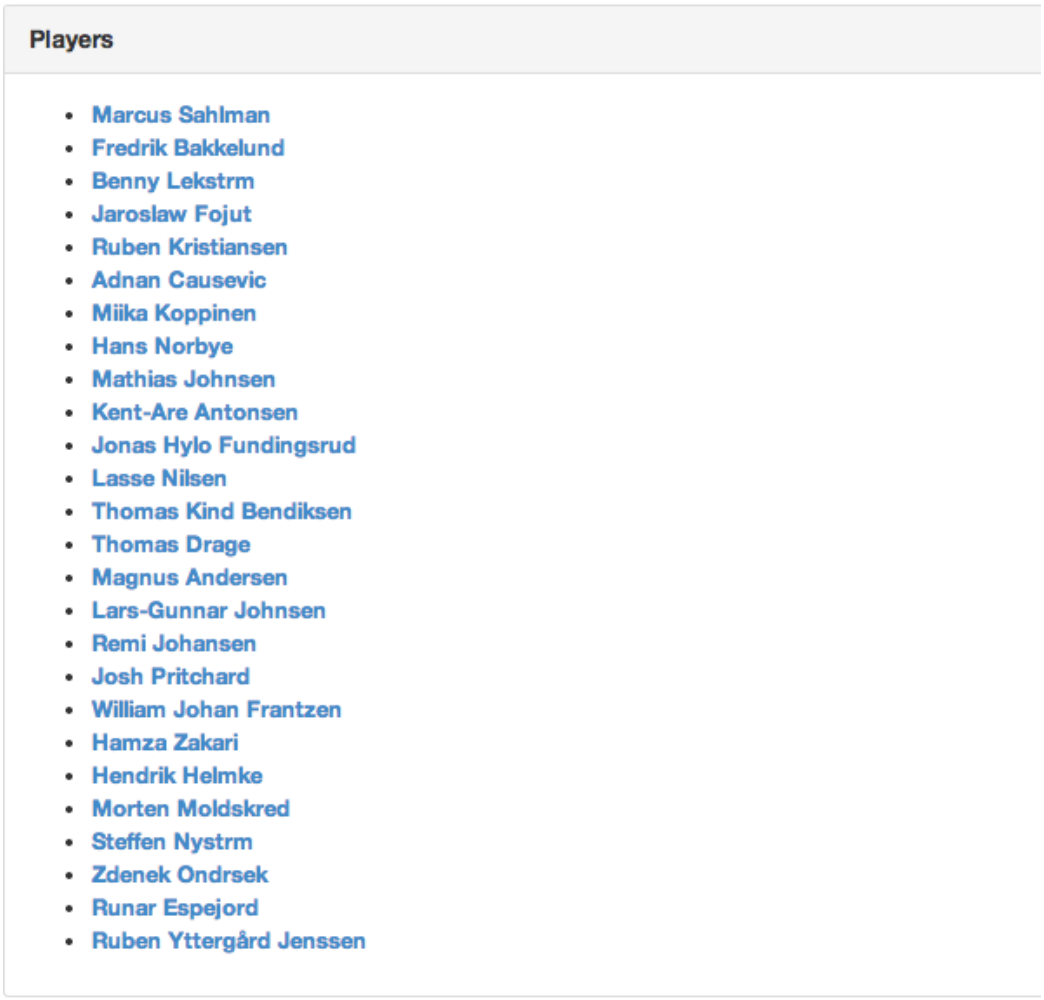

Figure 5.10: All players are listed below the team analytic page. Clicking on a player brings you to the player view.

5.1.9 Player view

Clicking on a player brings you to the player view shown in figure 5.11 and figure 5.12. Here individual statistics is highlighted. The pages shows who the player combines most with, number of breakthroughs, and zones where the player is involved.

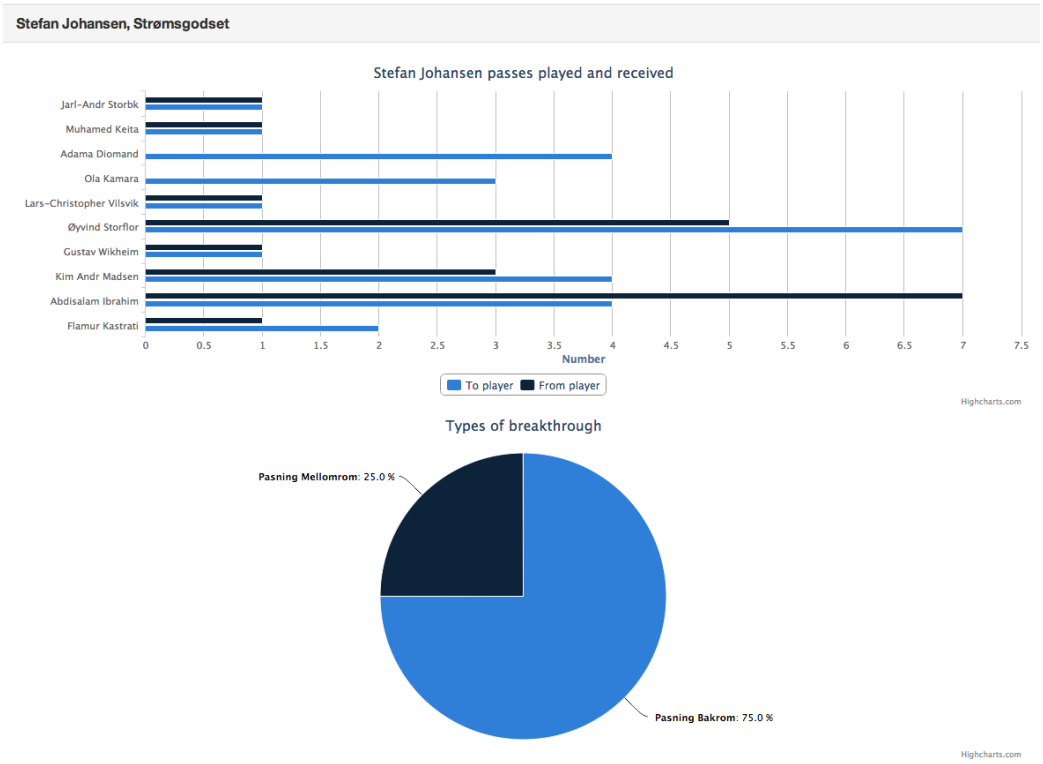

Figure 5.11: Player view highlighting individual statistics

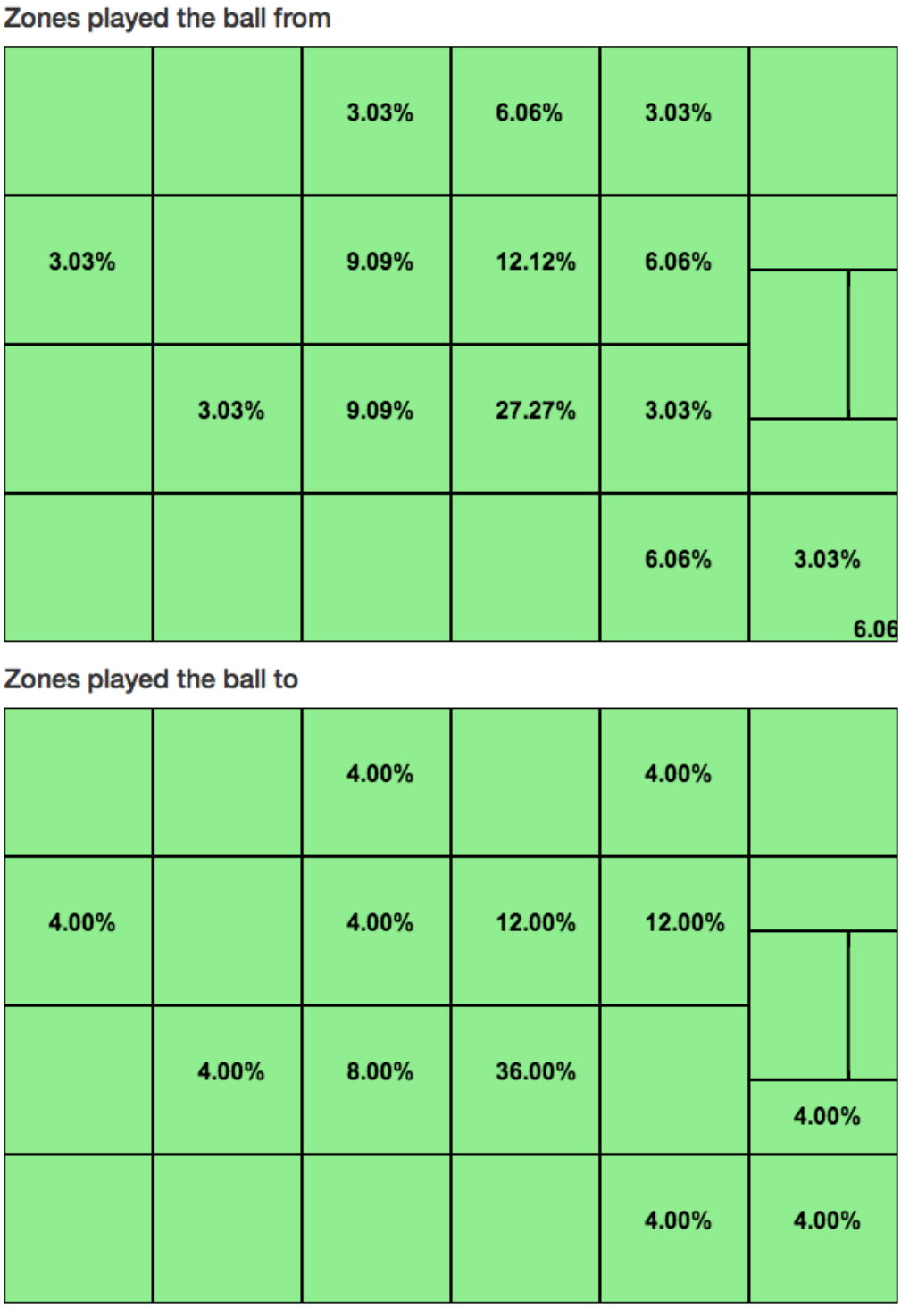

Figure 5.12: Player view highlighting individual statistics

5.2 Capturing process

As mentioned, the process of capturing data is manually. In the beginning it took up to 1 hour to capture all attacks for a match. When you get used to the interface and is able to quickly identify players the time used went down 15-20 minutes. Where most of the time went was getting the players id by looking up in the database manually. To speed up the capturing process the starting 11 names and their corresponding ID where written down with the formation the team plays in to a piece of paper before starting. This also helps identifying players, which can be a bit of a hassle. Match videos came in the resolution 640 * 360 pixels, which is not very good. In addition, on some stadiums there is a running track around the pitch meaning that the grand stands and the main camera is located further away from the pitch. It makes it even harder to identify players on the opposite side of the where the camera is. Having the formation of the team on a paper helps you to identify the players.

The process of capturing was as following:

1. Download the match video.
2. Find the match in the VGLive.no archives. VGLive.no is used to quickly find all attacks ending with a finish. Figure 5.13 shows some comments from a match.
3. Register the match by filling out the form in figure 5.3.
4. Start finding possible attacks to capture by using VGLive's annotations. Every event has a time tag in VGLive. This tag is often 1-2 minutes after the actual time of the event.
5. Capture every attack that leads to an attempt on goal one by one via the interface shown in figure 5.5.

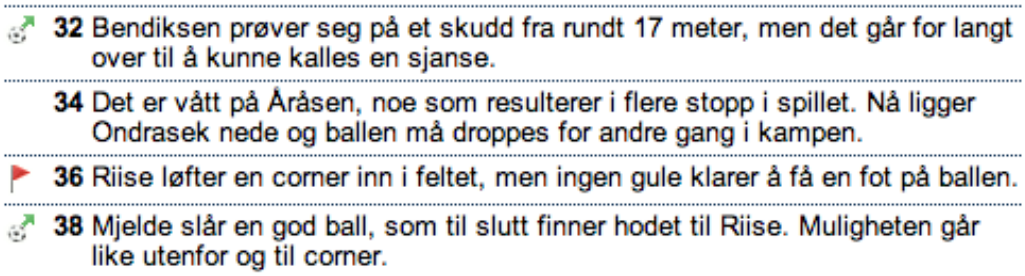

Figure 5.13: VGLive.no writes about events in the match. Attempts on goal are tagged with an icon. In the screenshot minute 32 and minute 38 has this icon.

Chapter 6

Evaluation and Results

This chapter presents methods used to evaluate the system; results collected evaluating the system and a discussion around the system.

6.1 Methods

6.1.1 User Survey

The system evaluation is measured by doing user surveys on the end users. In our user survey we have coaches and others with many years of experience in soccer rating how much they agree with a statement on a Likert-scale. The statements compare the system against other systems in use at Alfheim today and the system as a stand alone opponent analytic system. The Likert-scale chosen is a 5 point scale from *strongly disagree* to *strongly agree*.[1]. In short it will let each individual to note how much they disagree or agree with a particular statement.

We will also let assessors comment about the usability or other things of the system that will be taken into the evaluation.

6.1.2 UI Performance

Measuring User Interface (UI) Performance is way of measuring usability of the system. These two are directly linked up to each other [6]. A slow system

[1] http://www.simplypsychology.org/likert-scale.html

and unresponsive system decrease satisfaction and usability for the end-user. Foundings in [9] indicated that a response time of longer than 1000ms would decrease the satisfaction of the user. The thought-flow of the user will not be interrupted and therefor one can argue that the UI it's fast enough. We will use this threshold to evaluate our UI performance in the system.

To measure the UI Performance we use Google Chrome DevTools[2]. A web page is only fully loaded when all requests have been fully received. In our Single Page Application (SPA) new requests will be spawned after the Document Object Model (DOM) is loaded. Therefor, we run performance tests for both fully reload of the page, when the DOM is ready and when the users navigates in already rendered page, which will be the most typical way for the user to navigate to different pages.

6.1.3 Compatibility

In the requirement specification we stated that going for a web page would ensure compatibility and accessibility. Every device now has a web browser and therefor the page can be reached from anywhere as long as you have an Internet connection.

To test this we use PowerMapper[3] website testing and site mapping tool. This test checks a wide range of things like browser support, dead links and accessibility. We use it for compatibility testing for web browsers.

6.2 Experiments and Results

In the tests Tromsø Idrettslag (TIL) and external experts in soccer have been used to evaluate the system, in total 5 people. In the tests we are looking to see if we have achieved our goals listed in the requirements. To recapture the main goals; we wanted to create a system that difference it from the existing systems out there and at the same time provide information that can be used for opponent soccer analytic. We specifically wanted to identify key players.

[2]https://developers.google.com/chrome-developer-tools/
[3]http://try.powermapper.com/demo/sortsite

6.2.1 Database size

In figure 6.1 the size of the different indexes in the database is listed. Match related data is stored in the match, attack and pass index. The total size of those 3 indexes is 379.5kb and with a total of 12 matches in the database. This means that an average match stored takes around 31.6kb of storage.

Database size	Size (number of documents)
Match index	124.9kb (12)
Attack index	135.5kb (566)
Pass index	119.1kb (437)
Sum	**379.5kb (1015)**
Teams index	23.9kb (16)
Player index	155kb (445)
Total	558.4kb (1476)

Figure 6.1: Table with the size of each index and the total size of all indexes

6.2.2 Test data

In the evaluation the database had been populated with data from TIL and Strømsgodset matches. Only attacks from these two teams have been used to answer the user servey. A total of 34 attacks have been captured for Strømsgodset over 5 matches. For TIL a total of 42 attacks have been captured over 9 matches. Figure 6.2 lists all matches. Some matches include data from other teams than TIL and Strømsgodset. They have not been taken into consideration in the evaluating process.

6.2.3 SAT as a tool for opponent analytic

In this user servey the assessors where asked how SAT is as a complementary opponent analytic tool. In the requirement process we specified that the system should be a complementing tool and not a direct replacement of the systems in use. The results shown in figure 6.3 shows that most of the assessors values the information the system provides.

Match	Attacks registrated
Viking – Tromsø, 2013-05-26	8
Strømsgodset – Tromsø, 2013-06-29	5
Molde – Tromsø, 2013-06-10	14
Strømsgodset – Vålerenga, 2013-05-10	8
Strømsgodset – Start, 2013-10-07	8
Tromsø – Vålerenga, 2013-08-04	15
Tromsø – Start, 2013-09-29	6
Tromsø – Viking, 2013-10-19	14
Tromsø – Aalesund, 2013-08-18	12
Tromsø – Strømsgodset, 2013-11-03	15
Sarpsborg – Tromsø, 2013-09-22	5
Sogndal – Strømsgodset, 2013-09-27	13

Figure 6.2: Matches that have been captured and persisted into the database

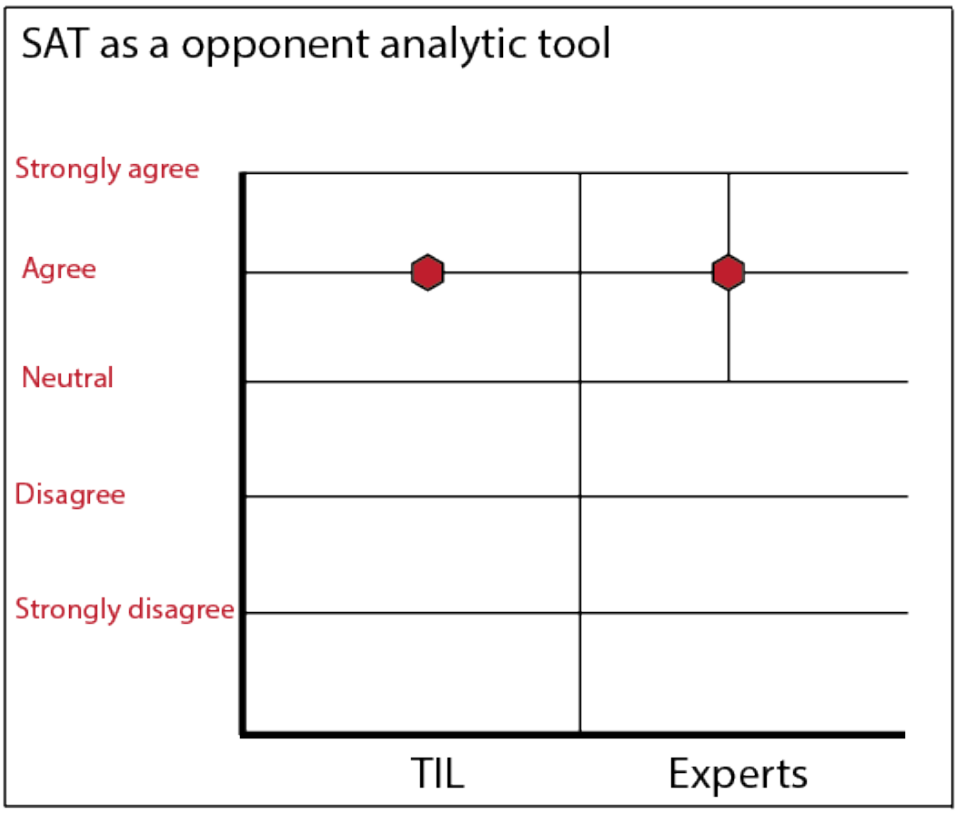

Figure 6.3: SAT as a tool for opponent analytic. Experts answers varying from neutral to strongly agree.

Assessors not in the TIL system do not necessarily use or have experience with an existing tool for opponent analytic. Therefor the statement was re-phrased. The assessors were asked how SAT is as an opponent analytic tool, a stand-alone product. The results listed at the right side in figure 6.3 shows that the majority of assessors was satisfied we the system with answers varying from neutral to strongly agree.

From these results we can conclude that the assessors view the Soccer Analytic Tool as a good system for providing information about soccer opponents. The assessors would have the system rather not having it.

6.2.4 SAT as a tool for identifying key players

In this user servey the assessors where asked how SAT is as a tool for identifying key players in a soccer team. This was one of the main goals of the system. The results of the user servey is shown in figure 6.4.

We can see from the results of the user servey that the assessors more than agrees that the system lets you identify key players in the opponent team. Assessors answers varying from neutral to strongly agree. From this we can conclude that by using the system, key players offensive in the opponent team is identified.

6.2.5 User servey comments

Assessors came with comments including to answering the user servey. These comments are summarized in figure 6.5. Two of the assessors would have liked improved graphic to illustrate the data. The UI haven't been the main focus in the process. The system is more as a proof of the domain model lets us get useful information for opponent analytic. Other comments is discussed in the discussion section.

6.2.6 UI-performance

UI performance was measured by testing the most content rich web page the team analytic page for TIL. All the response times were measured by doing 20 samples. Tests where run at localhost with server and database running on the same machine, meaning that a further increase in time would likely

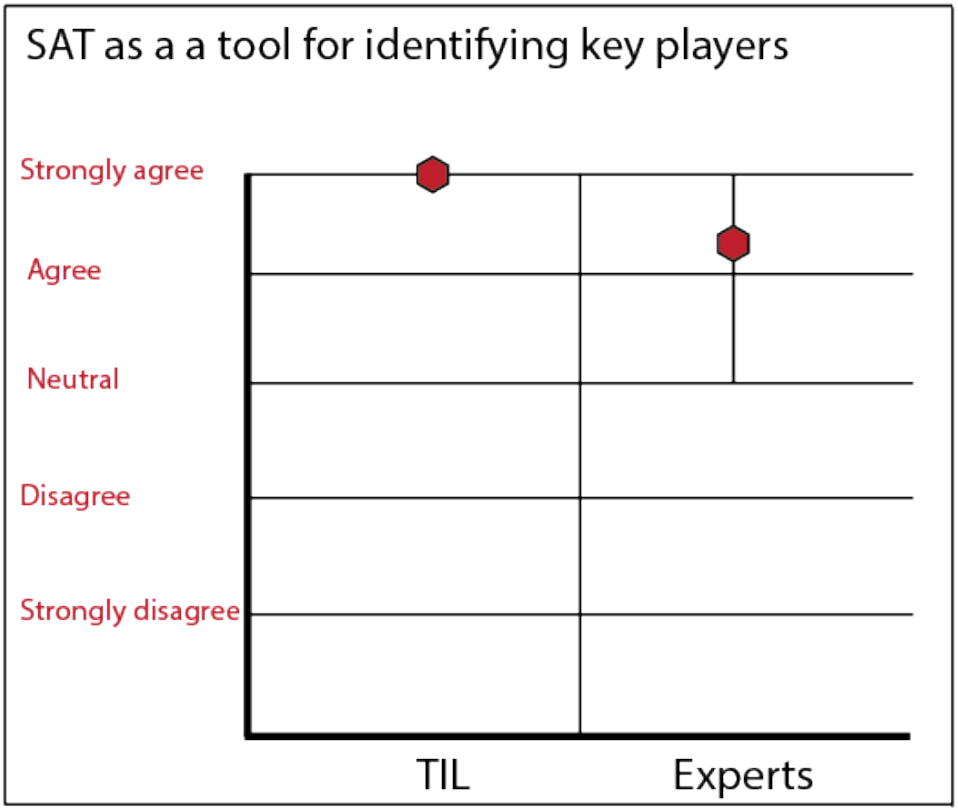

Figure 6.4: SAT as a tool for identifying key players. Experts answers varying from neutral to strongly agree.

Comments
- Improved graphics would have helped a lot on the overall experience of the system (2)
- Useful information to see which players to be extra aware of in the opponent team.
- How is data quality checked?
- Should have the ability to compare two teams on the same page

Figure 6.5: User servey comments

be seen if the system was in production. Total size of all requests on a full

reload was 1.6 MB. Figure 6.6 lists the results.

Interface	Avg response (ms)	Min (ms)	Max (ms)
Team analytic page (DOM loaded)	434,4	402	488
Team analytic page (everything loaded)	623	583	695

Figure 6.6: UI Performance test results.

Two tests were run to see the difference of a DOM load and a fully page load (all requests to the back-end done). The difference between the two is that in the latter we also add the time for the requests for team statistics as these requests are run when the JavaScript code is executed. The user will see that the page is loaded but is missing some content because of the team statistics requests.

The results show that we are well below the 1000ms threshold Nielsen [9] suggested. The maximum delay was 695 ms over the 20 samples for complete page load and 488 ms for DOM load.

The final test where a normal page navigation coming from the page listing all teams. This is the most typical way a user will arrive at the team analytic page. 3 specific requests goes to the back-end API when the team page is visited:

- */team/Tromsø/finalthird*: Passes into final third of the pitch.
- */teams/Tromsø*: Team statistics.
- */players/Tromsø*: Fetching all players.

In average it took 83.5ms for the slowest query of the above 3 to return over 20 samples when navigating from the teams page to the team page of TIL. Max delay was 102ms and min was 76 ms. This is well below the 1000ms threshold.

6.2.7 Compatibility

Figure 6.7 shows the result after running the page in different web browsers with the PowerMapper tool. The results show that the web page works in

most browsers except from some issues in older Internet Explorer versions. We can conclude that the page has good compatibility with different web browsers making in accessible on many platforms.

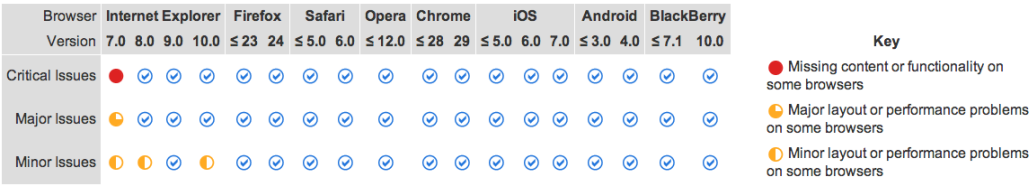

Figure 6.7: Compatibility test by running the web page in different browsers. Screenshot from powermapper.com free trial version

6.3 Discussion

6.3.1 Input

Perhaps the biggest limitation of the system is that it requires manual work to be functional. The system requires a lot of manually work to be operational as an opponent analytic tool. Up to one hour is the normal time spent capturing all data for a match with the current capture interface. On average, teams across the top four top leagues (La Liga, Premier League, Serie A and Bundesliga) took about 13 shots per match, measured in the 2010/11 season [11]. This means you will have possible have 26 attacks to capture for each match.

In section 5.2 it is mentioned that you have to store the players by their ID. IDs are only found in the database. Instead of this a player selector interface could have been developed letting you just click on an image of the player involved and the ID will be automatic inserted in. We suggest you can save up to 20 minutes by having this feature added.

6.3.2 Accuracy

There is minimal quality checking of the input data except from the match view page that lists every attack captured, meant for external operators to verify the data. Other than that you have to trust the operator that is capturing match data. The input is to some degree subjective for some

data like identifying breakthroughs. In some cases one operator may say that it was a breakthrough and another operator does not agree. This may not be the biggest problem if you set some rules to follow for the operators. Identifying the zone for an event can also be a bit tricky. Especially, in soccer stadiums that have a low camera angel when being filmed.

In our test data an average match is around 31.6kb size large, but we only capture attacks from one team. However, it is nothing in comparison with ZXY where a match is around 500-700mb. A more fear comparison would be against Optas data size for a match, as they are more in the same genre as our system, using only manual input. As previously mentioned, they capture every pass in the game meaning that they most likely store more data per match than our system.

6.3.3 Domain model

The domain model has been dedicated a lot of time to in the process of defining and building the system. It was crucial to have a domain model that reflected what type of opponent analytic information the system should give the end-user. What is enough data to store ? Having a larger domain model would increase time spent in the process of capturing data.

A thing that could have been changed to get more precise analytic information is how breakthroughs are represented in the database. The current solutions store each type of breakthrough as text saying where on the pitch the breakthrough came from. Rather than this, we could have taken advantage of the already defined dividing of the pitch. This would have given use more precise data to present to the end-user.

6.3.4 UI Performance

A thing to take into consideration is the amount of matches in the database under the tests. A system in production would contain a lot more matches and would increase the response time.

In a SPA you don't necessary get all the files at once, but when you need them. On render, the web browser will first get the root HyperText Markup Language (HTML) document and then start requesting all other files that is referenced in the document, like Cascaading Style Sheets (CSS) and JavaScript files. Bundling all JavaScript files can to one file would save a

lot of network traffic when doing a full reload of the page. Doing a complete reload of the team analytic page Google Developer Tools reports that total 55 requests is done to the back-end, fetching various files and requests to the REST API.

6.3.5 Usability

Several assessors noted that improving the graphical components would increase the overall experience of the system and make the system easier to use. This has not been one of the main focuses during the development of the system. However, from the results of the user servers the system must be to some degree usable in the way of the assessors find the information presented useful. In future work it would be naturally to focus more on usability of the client taking in Human-Computer Interaction in [13].

6.3.6 Scalability

Scalability has not been one of the requirements of the system. However, some simple tests were run to see how Elasticsearch handles new nodes joining the cluster. When adding a new node by starting a new instance of Elasticsearch, Elasticsearch started replicating shards to the new host. When setting the number of replicas to two, Elasticsearch started replicating immediately to achieve two replicas per shard, spreading it over different machines. In total 3 machines was up and running with shards. In this very simple test we saw that Elasticsearch can possible scale up by adding more hardware to handle more load, if this should be needed, and that it is configurable to handle your needs. Investigating more into this, checking how new nodes influences the response time, is left as future work.

Chapter 7

Conclusion

This chapter presents our achievements, gives some concluding remarks and outlines possible future work.

7.1 Achievements

In this project, we develop and evaluate a system for capturing, persisting and presenting information in the field of soccer opponent analysis. The problem definition is as follow:

This project will develop a system complementing the Muithu and Bagadus systems. Focus will be on soccer opponent analytics, where a data repository needs to be developed capturing important events relevant for this type of analytics. Especially we want to identify the key players offensive in a team. A user interface component presenting the core information about the opponent should also be developed and evaluated.

In the requirement specification we stated what we wanted from the system; a complementary opponent analytic system that among other things identifies key players in the offensive play of a soccer team. We wanted to be able to see where on the field the key players contribute. Including to this we wanted an interface for capturing events for soccer opponent analytic and estimate how long the process of capturing these events would take. Lastly, we needed to figure out what to capture from matches.

In the process we have been collaborating with Tromsø Idrettslag (TIL) to develop a domain model for our system resulting in several rounds of discus-

sions before settling. Some prototyping was done to illustrate different type of statistics the system could provide. In the end, we have built an interface for capturing attacks, a back-end exposing an API for storing and querying the data captured and an interface presenting this information.

In order to evaluate the system, user serverys was conducted with TIL and other experts in the domain of soccer. These assessors has been testing the system with real data from total 12 games where TIL and Strømsgodset have been involved. Assessors where asked to state how much they agree with different statements on a Likert-scale. From the evaluation results we can conclude that the assessors view the Soccer Analytic Tool as a tool able to provide useful information about soccer opponents, and especially to identify key players in the opponent team. The assessors would have the system rather than not having it. Expert assessors ratings variated from neutral to strongly agree for both statements.

When gathering test data we found out that a typical match takes around 45 minutes to capture with the current interface. We suggested that implementing a complementary interface for selecting players would decrease the time with 20 minutes. We also found out that the process of capturing attacks can be a bit of a hassle. A good video feed of the match with a high resolution would help in identifying players.

7.2 Concluding Remarks

Through the evaluation we can say that we accomplished to build a soccer opponent analytic tool. We would have liked more participants in the evaluation to be surer about the evaluation results. The assessors was however positive to the system.

Building a system for soccer is complex task. There are many different terms in the field making it hard to make a vocabulary for your system. In our system we decided to go for TILs terminology (in Norwegian) to avoid misunderstandings.

As a final remark we can say that using Node.js and Elasticsearch have been a joy, taking into consideration that both is relatively new platforms and technologies.

7.3 Future Work

Simple quality checks of the data can be added on the back-end to improve accuracy of the data:

- *Players*: In attacks with more than two passes is register. The attack start player should be the same as the sender of the first pass, or with no passes, the player finishing the attack.
- *Player IDs*: Checking that IDs for passes matches a ID for the specified team
- *Other*:

Including to this, the single match page could have been updated with delete and edit buttons for attacks for operators to be able to correct or delete wrong data.

There is still many possible queries than can be done on the data gathered. Examples include listing what type of passes players play; cross, pass, long ball. The same goes for type of finishes; shot miss, shot target or shot goal. This would need to be discussed with experts in the domain in order to quantify what can be useful. However, there are many possibilities left to explore.

Giving the end users the possibility to see statistics for two teams at the same time. The statistic for one team itself might not be so interesting if you don't have something to compare it to. Graphical components in the system could have had a way to select a team to compare with.

Another feature would be a team versus team page where two teams are compared up to each other.

On the back-end, better error handling is needed to be more robust. The current solution fails if you try to access a match that doesn't exist for example.

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