Web-based Interactive Visual Exploration of Dota2 Encounters

Wilma Weixelbaum*
Supervised by: Krešimir Matković†

TU Wien
Vienna / Austria

Abstract

In the last decade, the popularity of ESports has grown rapidly. The financial leader in the tournament scene is Dota2, a complex and strategic multiplayer game. The driving force behind a Dota2 match are encounters or teamfights between the two teams, which are often game deciding. Especially during a Teamfight, analysis is a challenging task due to the many actions and interactions between players. Available resources include the combat log, which logs every event at an atomic level, featuring great detail at the cost of readability, as well as concise third-party summaries that provide very little detail. What is missing is a middle ground that provides both a better representation of details and meaningful aggregations when it comes to Teamfights. This work therefore proposes a web-based visualization of the combat log focusing on interactions between players by using a directional graph. The result is Dota2 Rumble Flow, an interactive visualization for interaction-based Teamfight analysis, with higher granularity than a summary and better readability than an atomic log file.

Keywords: Interactive Visual Exploration of Teamfights, Graph Visualization, MOBA Game, Dota2

1 Introduction

Similar to traditional sports, professional ESports teams are competing in tournaments of varying size all around the globe with millions of spectators watching and following their progress [7]. The ESport scene is still expanding and can nowadays even be compared to sports like soccer, basketball or football. It is even more popular and established in Asia compared to the Western world [1]. For example, the annual Dota2 tournament The International (TI) with a combined value of 34,330,069.00 USD in 2019[1] has been in the same ballpark regarding tournament prize pools of sports tournaments for years and easily overtakes others in this domain. Dota2 is a popular Multiplayer Online Battle Arena (MOBA) game. These games typically feature very strategic gameplay and are highly competitive. They are designed to take place in a limited space that basically looks the same for every game, just like the board of a board-game stays the same. In the case of Dota2 the map is split diagonally between the Radiant side and the Dire. There are two teams with five players each and every player picks a character, also called hero or champion for the match. Ultimately, the goal is to destroy the enemy team's base. In order to do so, opposing heroes engage in combat with each other. It is necessary to fight and function well as a team to defeat the enemy heroes and emerge victorious from encounters. An encounter is called Teamfight if the majority of heroes are involved in it. During the fight, the heroes have several options to defeat the opposing team such as e.g. attacking them with the standard attack, using abilities that are unique to each hero or using items that can be obtained during the game. There are many factors that influence the outcome of a fight ranging from ability and item builds over positioning and communication to raw player skill. But what ultimately kills a hero is the damage that was taken. Damage has three different types: physical, magical and pure damage and will affect the champions differently. Those with high armor take less physical damage but might be prone to magical damage if they lack magic resistance. Pure damage on the other hand ignores armor as well as magic resistance. It is therefore interesting to know how much damage of which type was dealt and also where it came from. Upon death a hero loses Gold while the enemy heroes that contributed to the kill earn Gold. Since heroes die on both sides, the criteria to win a Teamfight is to earn more Gold from it than the other team.

Looking at a Dota2 match from a viewers perspective, it features a dramatic arc and tension which comes from the inevitable conflicts between the teams and their uncertain outcomes[2]. Teamfights are consequently an important part of the game in order to win and are also very exciting for spectators to watch. Thus they create motivation to look further into them. Teamfight summaries and the like of it are quite common, but they often neglect the time aspect and contain mostly aggregated statistical information. Visualizing this type of information is a common demand in order to increase readability and communicate the data in a clear way[8]. In this paper, we introduce the Dota2 Rumble Flow, an interactive graph visualization that is designed to help Teamfight analysis based on interac-

*w.weixelbaum@outlook.com
†matkovic@vrvis.at

[1] https://www.esportsearnings.com/tournaments, February 2021

tions between players. It efficiently fills the gap between detailed game logs, which are difficult to understand, and aggregated summaries, which often do not provide enough details for in-depth analysis.

2 Related Work

Visual analysis of sports has become increasingly popular recently. Du and Yuang [3] provide an overview of visualization and visual analysis of competitive sports. Another survey on visual analytics for sports is provided by Perin et.al [5]. Visualization approaches for dynamic graphs are discussed in the book 'Visualizing Graph Data' by Corey Lanum [4]. When it comes to logging actions, ESports offer an advantage over traditional sports because logging can be easily implemented. Since we are focusing on Dota2 in this paper, we will give a brief overview of data visualization and analysis tools for Dota2 data that are available online.

Teamfight summaries exist on various platforms and roughly capture what happened during a Teamfight. The Dota2 Fight Recap (see figure 1) is shown in game during a match to be viewed by players and spectators. First and foremost it shows the three most important variables: Gold, Experience and Damage. By displaying the values aggregated for every player as well as for the team the winners of a Teamfight can easily be recognized. Additionally, events like Hero Deaths are shown by displaying a skull icon directly underneath the hero picture. Lastly, the Fight Recap shows which and how often abilities and items were used by the players. The Fight Recap is usually shown while a game is still going, it is therefore convenient to only show information that can be processed quickly by humans. By summarizing the most important values and providing an aggregated view of the impacts made by each hero, the Fight Recap efficiently conveys this information to players and spectators. What the Fight Recap does not show is temporal information. It cannot show when or to whom damage was dealt, it does not distinguish between different damage types and damage from items, abilities or standard attacks. There is also no information about healing. The same is true for the opendota Teamfights View (see figure 2) which is essentially a more detailed Fight Recap, by extending it with information about healing and the Teamfight's location.

The Dotabuff Combat Tab is basically a web-based analysis tool consisting of components. The scope stretches over the whole game and thus the focus is not on isolated Teamfights, but information is offered in finer granularity too by e.g. distinguishing between damage types and giving information about Crowd Control. The first component is a summary of combat statistics, i.e. cumulative damage and healing, duration of crowd control, incoming and outgoing. The second component shows which abilities and attacks were used by each player and whom they were used on. It is called Combat Breakdown (see

Figure 1: Dota2 Fight Recap

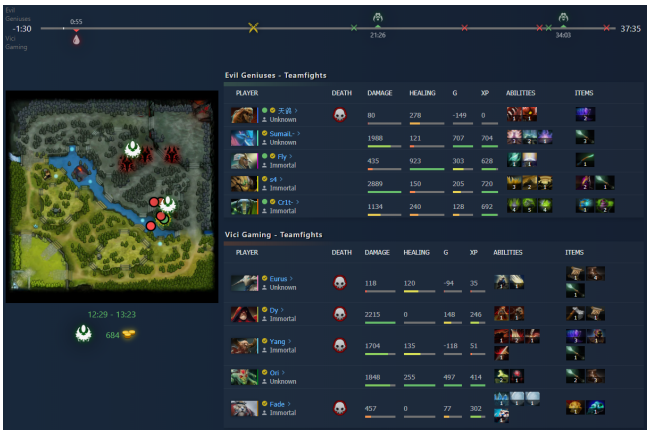

Figure 2: Teamfight Summary in opendota

figure 3) and shows one hero only. The third shows how much damage was dealt by a hero, distinguishing between standard attacks, items and abilities, also limited to one hero. The Dotabuff Combat Tab gives a whole lot of statistical information which is shown in tables with visual cues. There is a bigger focus on the interactions compared to the Teamfight summaries, but it does not convey the information of who dealt damage to whom, in a certain time frame, for each hero simultaneously, as this is hard to show in a table additionally to all the other aggregations. This also makes the Combat Tab a bit harder to read. Furthermore, it is not entirely for free, it is available only for professional matches or matches of users with a Dotabuff Plus subscription.

Another subscription service is Dota Plus. With the subscription one gains access to the Death Summary (see figure 4) amongst others. As the name suggests, events and effects that killed a hero are summarized. It shows how much damage was dealt to a hero as well as its source

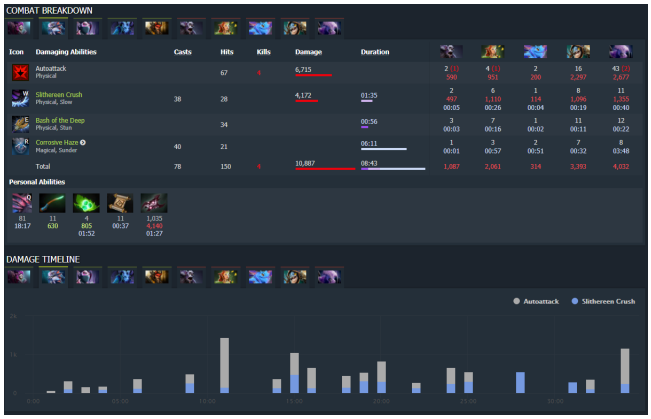

Figure 3: Dotabuff Combat Tab, Combat Breakdown and Damage Timeline

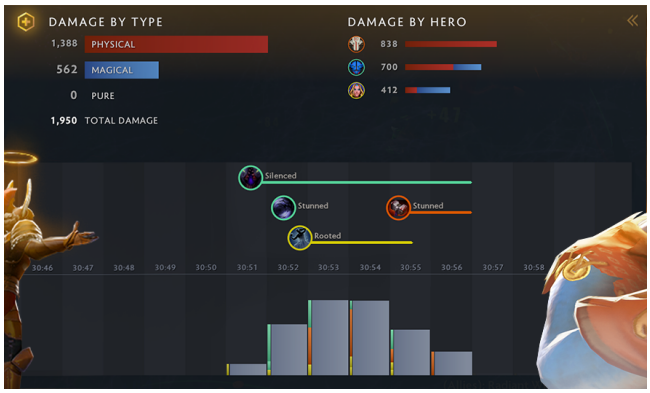

Figure 4: Dota Plus Death Summary, snippet from `https://steamcdn-a.akamaihd.net/apps/dota2/images/plus/bg_death.png` as promoted on `https://www.dota2.com/plus`, February 2021

(standard attack, ability, item) and what status effects were involved. Another aspect that the Death Summary brings to the table is the depiction of time. It shows at which time damage was dealt and during which timeframe status effects were active. Even though the raw information behind the Death Summary is very rich and detailed it is also easy to understand. Even so, only players with the Dota Plus subscription have access to this visualization therefore they cannot view the Death Summaries of fellow players but only their own. It therefore also lacks the display of all the heroes at once.

3 Data and Tasks

Thanks to the digital nature of ESports a lot of high quality data is available, because it can be treated as if it were collected from a lab-like environment[6]. Practically everything that happens during a match of Dota2 is logged and stored into a demo file that uses the Protobuf[2] format.

[2] `https://github.com/protocolbuffers/protobuf`, February 2021

These so-called replays can be downloaded from platforms like opendota[3], which also provide information on e.g. the timeframes of Teamfights in a match. By parsing a replay e.g. with the open source parser Clarity[4] one can access match data in high granularity.

Several questions arise when analyzing Teamfights. Basic ones would be, e.g., how much damage was dealt to a hero, how much was received, what type did the damage have and did it come from abilities, items or standard attacks, what about healing, etc. By going a bit deeper, we can also look at the progression of damage, e.g. see when a hero joined or left the Teamfight, when a hero was killed and by whom, if there are sudden bursts, if it was a long exchange of blows, also what hero was focused when by whom, if someone switched targets, etc. in order to better determine if the right decisions were made by the players.

By visualizing the interactions between the heroes during a Teamfight, not only can these questions be answered, but this also adds on to existing summaries by showing the context of the aggregated values in relation to the other heroes.

The interaction data is obtained from the parse and are basically a collection of 'events'. Every event has a timestamp and a type. While there are many different types of events, Damage, Critical Damage, Healing and Death are those that interest us. While Death events feature a Source and a Target, the former three event types additionally have an Inflictor, a value, as well as the damage type if available. Source and Target correspond to heroes, while the Inflictor contains the information whether an ability, item, or standard attack caused the event. The value indicates how high the damage or healing dealt was and the damage type distinguishes between physical, magical, and pure damage.

4 Visualization Design

Existing Teamfight summaries do a great job at answering overall questions regarding a Teamfight. Especially with subscription services from Dotabuff or Dota Plus a lot of insight can be gained from match and combat analysis. But the summaries give relatively few information about the progression of the fight. They show what happened, but not really when it happened. Detailed information can also be viewed for one hero at a time. We were looking for a possibility to show interactions, i.e. damage and healing events for all heroes at once. This is possible by preserving the timeline of a Teamfight, which also enables us to look at the progression of the fight. We propose an interactive graph based visualization: The Dota2 Rumble Flow (see figure 5). The Rumble Flow is first and foremost a node link diagram. The nodes of the graph correspond to the heroes, the links to damage or healing

[3] `https://www.opendota.com/`, February 2021

[4] `https://github.com/skadistats/clarity`, February 2021

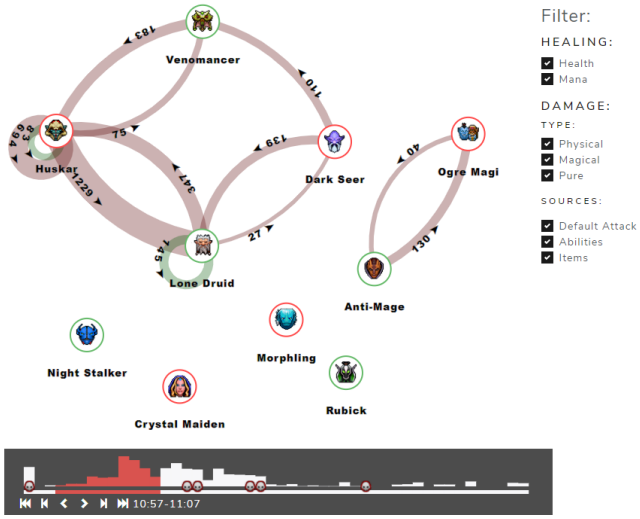

Figure 5: The Dota2 Rumble Flow, a node-link diagram with time controls at the bottom, filter at the side

events. To distinguish between the teams, the borders of the nodes are color coded consistently with Dota2's color scheme of Dire (red) and Radiant (green). Since a regular Dota2 match is always played with ten heroes, there are exactly ten nodes, incidentally keeping the graph clear and clutter free. The links are weighted with either the damage or healing value. The link label contains the exact amount as well as the directional information of a link.

With this setup, it is possible to view the interactions for all heroes at once, that happened in the same time frame. Looking at the red links in figure 5 we can see that there are in fact two isolated encounters happening at the same time. While Huskar, Dark Seer, Venomancer and Lone Druid are involved in the actual Teamfight, Anti-Mage and Ogre Magi only have a short and quick exchange of blows apart from the others. Looking at Huskar we see that his main damage output focuses on Lone Druid, but he also inflicts a lot of damage upon himself. With conventional Teamfight summaries that only show one cumulative value for hero damage, there is no differentiation between self-inflicted damage and damage inflicted on enemies. By showing and accumulating events as links between nodes, the Rumble Flow therefore adds context to a Teamfight summary. The Dota2 Rumble Flow also enables filtering between damage types and Sources (see figure 5), to help determine which combinations of these factors represented the biggest problems for each hero.

Below the node-link diagram the time controls are located. The module consists of five connected components which are a bar chart, indicators for hero deaths, a timeline, buttons to go forward and backward in time and the label for the current selected timeframe. The bar chart is located above the timeline and shows the overall damage ouptut for each second during a Teamfight. Skull symbols at the bottom of the bars indicate that a hero died at this point in time. Hovering above the icons shows which heroes were killed by whom. Lastly, the buttons at the bottom enable the user to walk through the fight bit by bit, which is also called time-based filtering [4]. With the default options of one, three, and ten seconds, timeframes can be selected in varying granularity. For the selected timeframe the corresponding parts of the bar chart and timeline are shown in red color. With the help of the bar chart and the skulls to navigate through the Teamfight, the busiest parts of it can be easily identified. Damage bursts, target switches made by the heroes and the moments when the heroes joined the fight can then be explored in greater detail in the node-link diagram.

5 Implementation

To implement the Rumble Flow, we had to gather the data first. We fetched the images from liquipedia[5] and opendota[6]. We modified the Clarity Replay Parser[7] which is written in Java to generate JSON files with the extracted events. To save disk space we only stored the events that occured during a Teamfight. The information on how many Teamfights were in a match and when they took place was fetched from the opendota API[8]. From there we also extracted general information i.e. what heroes were picked for the match. We used a PostgreSQL database to access the data from our Django web application. For the frontend we used React to structure the interface in combination with the D3.js library which was used for the timeline and bar chart as well as the node link diagram. Based on the data it was clear that damage could flow between two nodes in either direction, which is why we implemented the links as arcs in D3. The width of the links corresponds to the value of the events that it represents. Therefore we decided to put the directional information into the link label, in order to avoid huge arrows. The library also supports force fields which help to arrange the nodes initially, but they can be dragged around as well.

6 Evaluation

In order to evaluate the visualization, we conducted interviews within the scope of a short user study of five participants. As the visualization is primarily made for Dota2 players, all participants have played the game before, although the degree of expertise varied.

First we asked the users if they analysed their matches in the past and about their approach when they do so. Aside from looking at match summary information that can be viewed directly in the game client after a match is concluded, they were all familiar with either Dotabuff

[5] https://liquipedia.net/commons/Main_Page, March 2021

[6] https://github.com/odota, March 2021

[7] https://github.com/skadistats/clarity, March 2021

[8] https://docs.opendota.com/

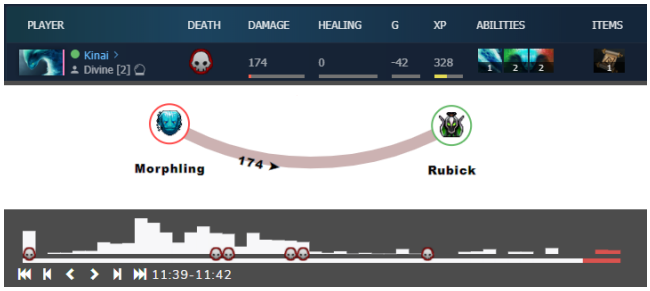

Figure 6: **Above:** Information on the hero Morphling as shown in the opendota Teamfight summary. **Below:** The Dota2 Rumble Flow displaying that Morphling dealt damage only after he died at the beginning of the fight as he had to wait to respawn.

or opendota and used those platforms for additional information. But depending on the analysis task statistics and summaries sometimes are not enough. Four out of five participants have therefore also downloaded and watched replays in the past in order to analyse the actions of themselves and their teammates in greater detail. In that case, the participants reported that they usually look for specific moments which are often Teamfights. When analysing a Teamfight this way, they pay attention to the participants of the fight, especially their positioning, when someone joined or abandoned the fight, who focused whom as well as item and ability usage.

After this first part of the interview, the participants were given several tasks to solve with the help of the Rumble Flow and/or the opendota Teamfight summary. The more experienced players were able to extract a lot of information from the summaries and make some assumptions about the Teamfights, but due to the limitations of high level summaries, those assumptions sometimes turned out to be quite false. While we used two matches and five Teamfights, we want to emphasize the following three scenarios.

6.1 Scenario: Morphling's damage

Figure 6 shows summarized information from opendota for the hero Morphling as well as a selected timeframe from the Rumble Flow. Based on the information from opendota all participants assumed that Morphling dealt a little bit of damage before he died. By hovering over the skull symbols in the Rumble Flow, they quickly found out when the hero died, which was in the first second of the fight. All five participants looked for Morphling's outgoing damage links at the beginning of the fight, but by exploring the rest of the Teamfight with the time controls, they saw that Morphling's damage was in fact dealt at the very end of the fight. Three out of five users felt that the information from the summary was misleading, because the hero's actions were not related to the actual fight.

6.2 Scenario: Huskar's impact

Another interesting Teamfight can be seen in Figure 7. It shows an opendota Teamfight summary and a Rumble Flow snippet of the same Teamfight. We asked how many heroes participated in the fight and which heroes had the most impact. Based on the summary, the answers were always: nine heroes with Huskar, Night Stalker and Lone Druid as the most impactful heroes, because of their damage and healing output. But by exploring the Teamfight with Rumble Flow, smaller numbers of heroes that fought in the Teamfight were reported. Two participants said eight heroes were in the fight. The other three divided the information further and said it was six plus two, because they saw two distinct fights. Basically they found out that Huskar did not participate in the fight at all and only dealt a lot of damage and healing to himself at the time. Huskar is therefore shown in the summary as the hero with the most damage and healing output. All participants stated, that the information from the summary was misleading, because once again, the hero's actions were not related to the actual fight. Even more so, he did not even partake, but was perceived as having had the most impact on the Teamfight. This highlights the importance of context when looking at the heroes' actions, which is not provided by high level summaries.

6.3 Scenario: Dire's loss

We also let the participants analyse a whole Teamfight with the information from both opendota and the Rumble Flow (see Figure 8). For this task we selected a Teamfight with significant impact, i.e. the game was pretty level before the fight and put the winning team into quite a lead after it. The questions we asked focused on the reasons behind the outcome and engaged the participants to find explanations for them. The Teamfight summary gave the users a quick overview of the aftermath, as all participants immediately saw that the whole Dire team was defeated. Two out of five stated that the Dire did not or could not use important abilities on some heroes and all participants made guesses about how the fight has played out. By exploring that same Teamfight with the Rumble Flow, they were able to draw more conclusions. The participants were interested in who joined the fight when and who was focused i.e. who received a lot of damage by enemy heroes. With this information, the participants argued, that Dire lost the fight, because one of their main damage dealers (Morphling) was defeated before the rest of team Dire joined the fight. They discovered that Morphling was engaged by the Radiant team for thirteen seconds before he died and the other Dire heroes joined the fight one after another, once Morphling had already been killed. Team Dire died in the same order as they joined the fight. Based on these insights, four out of five participants said that Dire should not have joined the fight after Morphling died. All agreed that Morphling should not have been alone for that

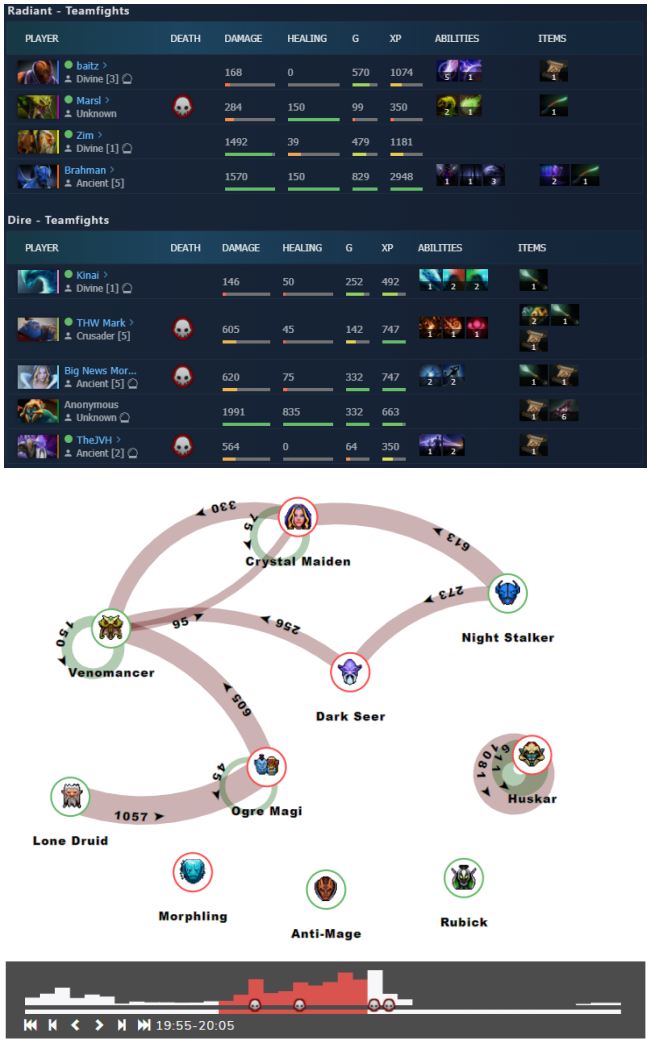

Figure 7: **Above:** An opendota Teamfight summary, showing that Huskar had the highest damage and healing output in the fight. **Below:** The Dota2 Rumble Flow displaying the same Teamfight, showing Huskar's damage is not inflicted upon enemy heroes, but on Huskar himself.

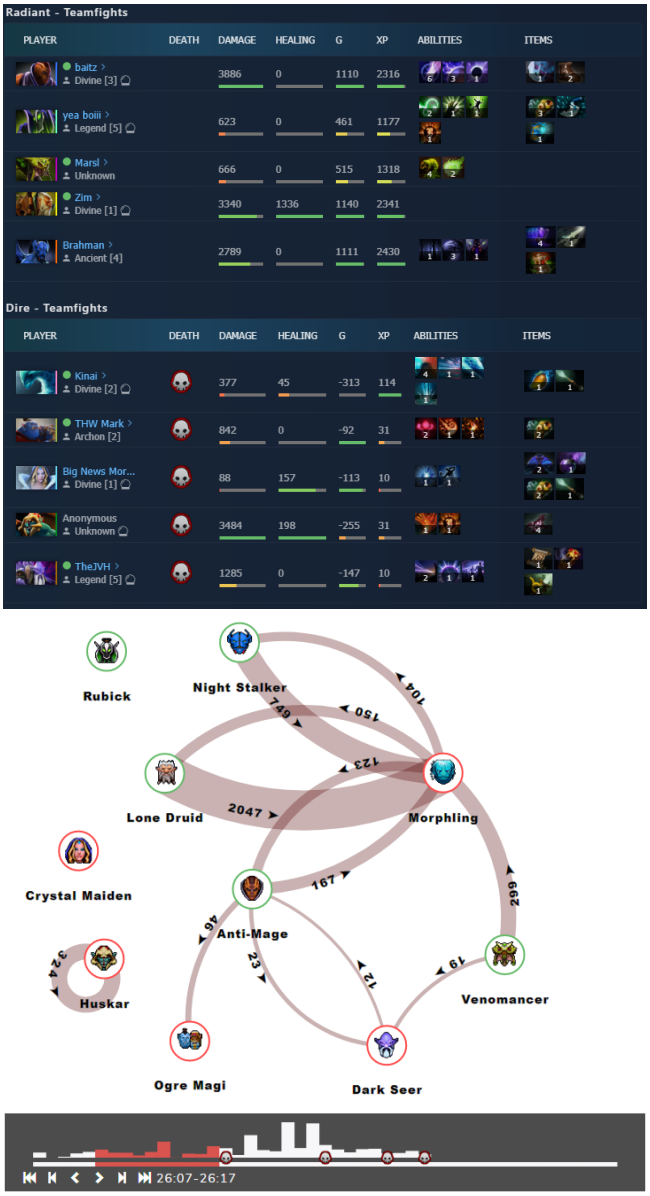

Figure 8: **Above:** An opendota Teamfight summary, featuring a complete wipe of the Dire team. **Below:** The Dota2 Rumble Flow displaying ten seconds of the same Teamfight that lead up to Morphling's death.

long, but to further analyse the reasons behind that, they would have needed information on the positioning of all the heroes. While the participants used the summary as well as the Rumble Flow in combination, they drew a lot of information from the Rumble Flow in order to find explanations for the Teamfight's outcome.

We concluded the interview with questions about the user interface, as the participants were already familiar with it by then. We received very positive feedback for the node link diagram as information is shown in greater detail compared to a summary. In combination with the skulls that indicate hero deaths along the timeline, participants stated that they were able to easily explore and navigate through the Teamfight. Interestingly enough, they did not really pay attention to the damage bar chart, because they drew the damage information from the node link diagram anyway. But they all agreed that it is nice to have, in order to find the busiest parts of a fight. They felt the same way about the filters, which only two participants used during exploration. The time controls were sufficient and we received suggestions to improve them further, e.g. by being able to select a timeframe per mouse drag as well as the whole fight. Generally, being able to explore the fight bit by bit and see the flow of interactions was very well-received. Further suggestions involved e.g. to visually mark nodes if the respective heroes are currently dead, and incorporate damage type information into the links between nodes. The participants also stated that information on items and abilities is missing, as the Rumble Flow does not show when items or abilities were used and

neither by whom. Another relevant aspect is the information about positioning, which is also not provided by the Rumble Flow, but would make an important addition for better Teamfight analysis.

7 Conclusion

The Dota2 Rumble Flow is an interactive graph based visualization that supports Teamfight analysis. It does not replace conventional Teamfight summaries, but instead benefits from them as they provide more information and context. In return the Rumble Flow provides more insight into the progression of a fight and can clarify the significance of aggregated values from summaries. It can reinforce right and refute false assumptions that are made from solely looking at summaries. Even so, the Rumble Flow can be further improved. Based on the results of the user study, the most important additions include information on hero positioning, and item and ability usage in greater detail. Aside from showing which items and abilities were used at which point by whom and on who, the Rumble Flow could further be extended with information about cooldowns and possibly even cast ranges.

Information on crowd control represent another possible improvement. During a Dota2 match it is important to use the right disables on the right target, which is often game deciding. Therefore status effects and their duration are very interesting for Teamfight analysis as well.

In order to keep the Rumble Flow comprehensible it might be reasonable to add new visualizations and further utilize the concept of focus and context.

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