Overview.
Statistics have been recorded about every basketball game ever played in the NBA, dating back the league’s first game in 1946.\(^1\) As is true for most professional sport leagues, these stats describe important events that took place during a game – in the NBA’s case, they are things like shot attempts, points scored, assists, etc. Traditionally, these are recorded by a human with a tally sheet, and only provide a surface view of the game – only certain events are recorded. New player tracking technology now allows for much more granular resource selection to occur, automating and transforming the basketball statistic-taking process to allow interactions that were not previously possible to aid team strategy and illuminate the game as a whole.

What is being organized?
The game of basketball is its own organizing system in which the teams organize their players in pursuit of a common goal – namely to score and prevent the other team from scoring. During a game, many events occur as these players move and interact in different ways, yet most of these events leave no trace, and most are too burdensome or subtle for human statisticians to record.

Player tracking technology is able to outperform human agents by creating real-time digital representations of the physical resources of a basketball game, namely the 10 players and ball on the court\(^2\). From there, interaction resources are selected based on the movement patterns of these digital representations, enabling the detection of the more subtle aspects of the game. This system is able to view a game as a coach might, recognizing things like screens, dribbles, different defensive structures, and more.\(^3\)

From the plethora of interaction resources that this system selects, proprietary software organizes them to create description resources that describe the game on almost any desired level of granularity. Users of the software can generate statistical reports for a whole team or individual player, and easily create visualizations to illustrate a point. During a game, the software can show a team things like: where a given player has shot the ball in the last quarter, which of their players has had the greatest defensive impact in the game, or even how far a player has traveled on the court over the entire season.\(^4\) Thus, the system enables users to quantify aspects of the game that were previously unquantifiable.

Why is it being organized?
Basketball is a highly competitive sport, and professional teams with a lot of money at stake will go to great lengths to get an upper hand on their opponents. Therefore, a deep understanding of the game to enable smart strategy is paramount. Player tracking technology provides a way for the complexities of the game to be better captured and quantified, enabling teams to employ new data-driven strategy approaches.
All coaches know the concept of ‘good’ and ‘bad’ shots – it’s obviously easier to make an open layup than a contested 3-point shot. By capturing a great deal of information about shots, player tracking enables a deeper understanding of player performance through more relevant statistics, one such being Quantified Shot Quality (qSQ). This metric describes the difficulty of a given shot, expressed as a percentage telling how often the average NBA player would make that shot under those particular conditions. This metric helps distinguish between shooters who get easy looks and those that make tough shots, even though they may have the same field goal percentage. This is highly relevant to teams considering offering a player a multimillion-dollar deal.5

In addition to better understanding player performance, this new data also illuminates team strategy as a whole. Coaches now have access to data that quantify the effectiveness of different defensive strategies against a given team or player. Teams have used this data-driven approach to discover new strategies that have helped them win playoff series.6

How much is it being organized?
The scope of this organizing system covers every game played in the NBA, and at its core, it tracks only the location of the ball and 10 players on the court at a rate of 25 times per second. 800,000 data points are collected per game, totaling around 1 billion over a season.7

The interaction resources created are organized to create a wide range of description resources at different levels of focus, describing individual players, games, or entire teams. For example, traditional field goal attempts can now be automatically categorized at higher granularity, distinguishing catch-and-shoot shots, to shots taken off the dribble, to drives and more.

When is it being organized?
Player tracking delivers multiple options for data streams in real time, organizing the interaction resources on a play-by-play basis. Proprietary software allows teams and media outlets to interact with the data during or after a game to access desired description resources as needed.8

How or by whom is it being organized?
Six cameras installed in all NBA arenas track the positions of the 10 players and ball on the court in real time, to collect an abundance of data about the interactions in a game. From there, proprietary software utilizes spatiotemporal pattern matching and machine learning to recognize and select the interaction resources from the game, collecting data about many aspects of each event on the court. After these interaction resources have been computationally classified, the software allows for the creation of description resources to describe virtually any aspect of the game in question.

Where is it being organized?
As discussed above, the Player Tracking system provides multiple options of data streams. For most users, the interaction resources are organized by the proprietary software of the player tracking system itself, thus the information is organized by the system in the NBA arena that
the game is played in. Player tracking information is also stored in a historical database, enabling users to view information about past games and seasons.9

Other considerations.
While this case study focuses on the NBA, player tracking is being used in many different sports, and provides an example of how automation is transforming many parts of human life. With machines being built that can understand the game at a deep level, it stands to reason that automation may soon seep into other aspects of sports. Automated referees could be coming, making ‘missed calls’ a thing of the past.

Beyond sports, the spatiotemporal pattern matching that enables this organizing system may soon be applied in other areas. At its core, player tracking technology tracks and categorizes movement, thus many of the same techniques could be applied elsewhere to situations in which understanding the movement of things is important. As Rajiv Maheswaran, CEO of Second Spectrum10, explains, “I believe that with the development of the science of moving dots, we will move better. We will move smarter. We will move forward.”11

8 "Sports Data Services." STATS. <www.stats.com/data-feeds-packages/>
Artifact: How does player tracking enable a deeper understanding of NBA players?

Description: In addressing the ‘why’ question of my case study, I claim that this system allows for more relevant metrics to be computed than were previously possible, giving teams a better understanding of the game and its players. To illustrate this point, I briefly describe Quantified Shot Quality, a new metric that describes the degree of difficulty of a particular shot. The info-graphic above shows the multitude information that is taken into account to compute this statistic, including the distance and speed of defenders, number of dribbles, shot angle, and more.

### quantified Shot Quality (qSQ) : 2015-16 Regular Season

<table>
<thead>
<tr>
<th>TOP 5</th>
<th>qSQ</th>
<th>BOTTOM 5</th>
<th>qSQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeAndre Jordan</td>
<td>65.0</td>
<td>Kobe Bryant</td>
<td>44.1</td>
</tr>
<tr>
<td>Dwight Howard</td>
<td>58.5</td>
<td>Marc Gasol</td>
<td>44.5</td>
</tr>
<tr>
<td>Kent Bazemore</td>
<td>55.9</td>
<td>DeMar DeRozan</td>
<td>44.5</td>
</tr>
<tr>
<td>Kenneth Faried</td>
<td>55.9</td>
<td>Carmelo Anthony</td>
<td>44.6</td>
</tr>
<tr>
<td>Draymond Green</td>
<td>55.9</td>
<td>Jamal Crawford</td>
<td>44.7</td>
</tr>
</tbody>
</table>
The above table shows how an aggregation of the qSQ metric over a season can provide a new way in which to compare player performance. Qualitatively, viewers of basketball know that DeAndre Jordan shoots high percentage shots – in fact, most of them are dunks. The qSQ metric now provides a quantitative measure for this aspect of the game, and sure enough he had by far the highest qSQ of the 2015-2016 season. On the same note, I can now quantitatively say that Kobe Bryant’s shots over that season were on average the highest degree of difficulty in the league.

Video Link: [https://vimeo.com/152740765](https://vimeo.com/152740765)

Above is a screenshot from a video (link above) that demonstrates how the qSQ metric can be used to better understand specific plays. The screenshot shows Russell Westbrook taking a highly contested shot, with the qSQ of that particular shot overlaid on the video. Both the video footage of that shot and the computed qSQ value both describe a specific event that happened in the game, thus the video footage augmented with the qSQ description resource is an effective way of showing how previously unquantifiable things (i.e. the quality of a shot) can now be quantified with player tracking technology.