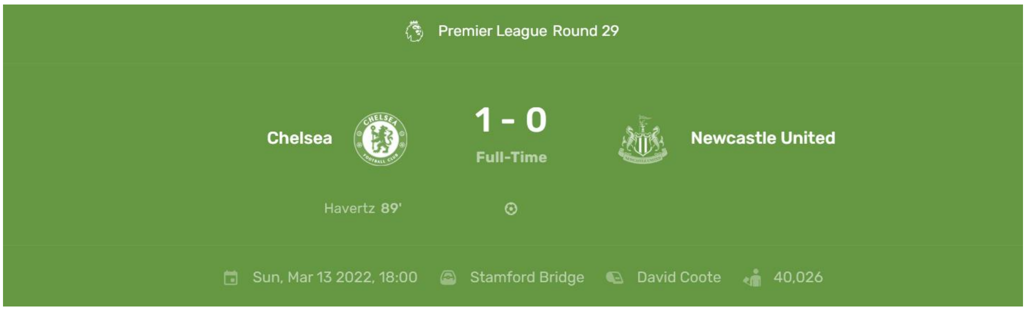
الجامعة الأمريكية في رأس الخيمة
AMERICAN UNIVERSITY OF RAS AL KHAIMAH

Project Report

Football Match Analysis Based on Players' Passing Networks

Match 1



Match 2

Team	ID
[redacted]	[redacted]
[redacted]	[redacted]

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Course: Discrete Mathematics

Submission Date: 5 December 2022 (Fall)

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Foreword

For over a century, football (soccer, to Americans) has been played all around the world. With millions of worldwide fans, there are now numerous local, regional, and global football championships and competitions. Most recognizable are FIFA World Cup (Fédération Internationale de Football Association), EPL (English Premier League), LaLiga (Spanish Football League), and UEFA Champions League (Union of European Football Associations).

Although there are several rules by which this sport can be played, the standardized and most popular one consists of 1 ball, 2 opposing squads with 11 players on each and some more on the benches for any necessary substitutions. Each team player gets assigned a position to fulfil during the game, the collection of these assigned positions and their corresponding players are called the team's formation. Football formations are imperative to the performance and quality of game the squad offers. While players play the game physically, managers play the mind-game aspect of the sport through formations. The momentum of the game can be quite literally controlled wholly by formations, as they have an influence over the chemistry between the squad, the offensive/defensive strategy of their playstyle, and many other details we shall discover along the way.

Sports involving interactions (in the form of passes, in our case) between players are an example of networks. That is why, in this project, and in line with the topics covered in this course throughout the semester, we are tasked to study 2 English Premier League football matches in order to conduct an analysis of the evolution of players' passing networks over time and the overall performance of the squads and their most actively contributing players by utilizing the mathematical and scientific theories of networks to obtain statistical data. In both given matches, Chelsea football club is a player (and a winner, as we will soon see), so it will be given special focus during all the to-be-conducted analyses. We will perceive how Chelsea's squad performs against 2 different playing formations by playing 2 different formations themselves. More on the objectives will be discussed in the coming pages. Finally, this project package includes:

1. 1 Excel file comprised of 3 sheets one for each match containing the collected passing and interception data and a sheet with the full name of the player corresponding to their number in the passing matrix table as well as their position on the field.
2. 2 annotated Python code files (one for each game) to run and verify the functionality of the code in producing results. Note, however, that all the relevant information needed to make sense of the analysis and commentary is attached in screenshot form for convenience and a better reading experience. Also, we will be explaining the technicalities of every step of the process and the meaning behind each of the obtained results. We have used Anaconda's open-source IDE Jupyter Notebook to write and run the code.
3. 1 Word file (this one) containing analysis of all obtained results from the code.
4. A .jpg photo of a football pitch needed because we have set it as the background of our graphs in the code.
5. A .pdf file scan of the data collection process. We used the number of the player then an arrow to the number of the player whom the ball got passed to. Squares around the numbers denote interceptions.

General Insights on Both Matches

➢ 1st Match

On 13 March 2022, *Chelsea* and *Newcastle United* played a total of 94:16 minutes during which Chelsea's Centre Forward player **Kai Havertz** scored the one winning goal in the minute 88:36.

➢ 2nd Match

On 27 August 2022, *Chelsea* and *Leicester City* played a total of 94:59 minutes during which Chelsea's Centre Forward player **Raheem Sterling** scored the 2 winning goals for Chelsea; one at the minute 46:10 and the other at the minute 62:06 of the game. In addition to that, Leicester City's Left Winger **Harvey Barnes** was able to score one goal in the minute 65:39.

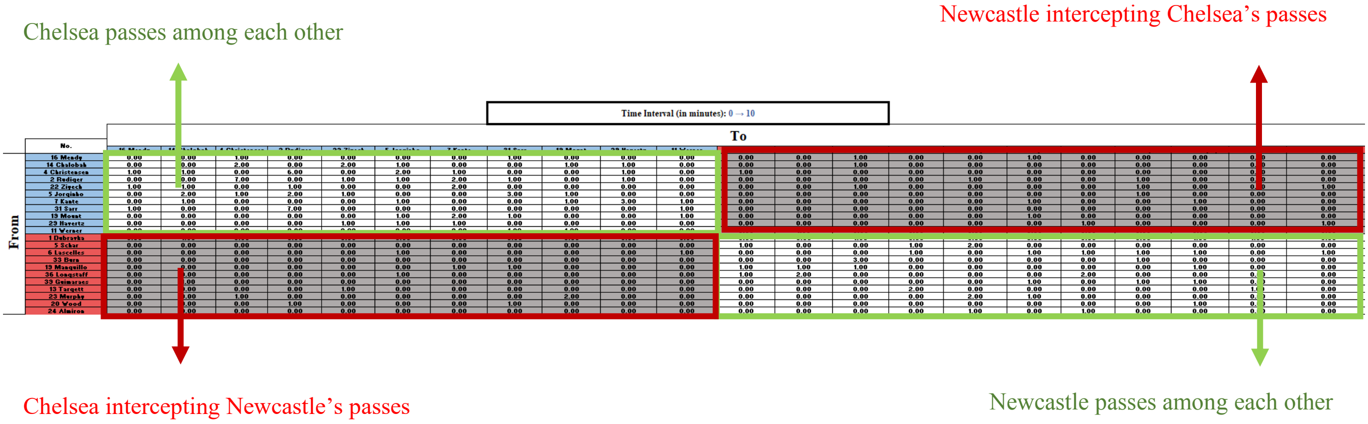
Objectives & Our Unique Approach

Notable is that Chelsea was the winning squad in both matches and that surely makes up for a team worthy of close-up studying. That is why we will be providing extra observations/analysis of the team's compatibility, performance, and strategy against different teams in the conclusion. Not only because they are the winning team, but also because seeing only one match for each of the other teams in not enough to draw well-informed generalizations and conclusions about them, whereas observing Chelsea playing for 180+ minutes is somewhat sufficient to start detecting patterns and making analyses, especially that we will be able to compare the information deduced from the collected data in both matches.

After watching the assigned matches, collecting passing data, and writing Python code containing several performance measurement formulas (discussed in the below table) and graphing/visualization functions, we should be able to:

1. Determine the passing characteristics of playing positions.
2. Determine clustering effects on the network.
3. Analyse a team's formation influence on their interaction (i.e., their passing network).
4. Give educated assumptions as to why the team changed formation during the game, if applicable.
5. Analyse how change in formation changes the centrality measurements of the players and affects the overall performance of the squad.
6. Make a comparison analysis of the evolution of the two teams' passing networks.

We have concluded the following: In order to study how effective the strategy and style of the team is, we must analyse the interactions taken between the players. Thus, we cannot study the importance of one node (representing one player) individually, instead you must study its importance relative to the whole network of the team (i.e., all the other nodes in its same network). And, in order to analyse how the strategy of a team adapts to different teams, you must study the interactions that happen between the teams (in form of ball interceptions), and in order to do that, studying the networks of both teams separately is useless, instead, we must study both networks at the same time; combine the passing matrices of both teams; create a network of networks. This is simply the reasoning behind our approach of data collection: Have only one directed matrix containing every player on the field instead of having 2 separate directed matrices one for each team alone. As our table of passes contains the interceptions as well, then 1 table for 1 time interval can be broken down into 4 main parts; team 1 passes among each other, team 2 passes among each other, team 2 intercepting team 1 passes, and team 1 intercepting team 2 passes. Using this matrix, we were able to build weighted and directed networks. Attached is an annotated screenshot example of one table (1st table of 1st match) and how data are divided in it.



Noteworthy is that we have opted for making our own data collection file as we've detected several incorrect data in the sample file. We've assumed it must be a sample of an old match and not our exact one. Among the submitted files, there is a pdf scan of our data collection process for both matches. As per the instructions, we have broken down the data collection and, consequently, the analysis into 10-minute time intervals. However, we have two 5-minute time intervals; (40-45) and (45-50) and that is because halftime occurs in the middle and our code has a concept of teams switching sides of on the pitch between 1st and 2nd half to represent the policies of the real-life game, so it isn't possible to give a player 2 different positions unless we separate the 2 halves.

As a sanity check, we have decided to utilize fotmob as a reference to give us a general indication of whether our conclusions are reasonable and in agreement with the information available online summing up the performance of the teams. And, as a sanity check for the code, we have included a footnote in the code of the 2nd match of how one can verify the obtained results from the calculations and the graphs correspond to the numbers present in our collected data file.

Chelsea vs. Newcastle United

Chelsea's Squad			Newcastle's Squad		
Position	Name	Number	Position	Name	Number
Goalkeeper	Edouard Mendy	16	Goalkeeper	Martin Dubravka	1
Right Back	Trevoh Chalobah	14	Center Back	Fabian Schar	5
Center Back	Andreas Christensen	4	Center Back	Jamaal Lascelles	6
Center Back	Antonio Rudiger	2	Center Back	Daniel Burn	33
Right Wing	Hakim Ziyech	22	Right Back	Javier Manquilo	19
Center Midfield	Jorginho	5	Center Midfield	Sean Longstaff	36
Center Midfield	N'Golo Kante	7	Center Midfield	Bruno Guimaraes	39
Left Back	Malang Sarr	31	Left Back	Matt Targett	13
Center Midfield	Mason Mount	19	Left Midfield	Jacob Murphy	23
Center Forward	Kai Havertz	29	Striker	Chris Wood	20
Left Wing	Timo Werner	11	Right Midfield	Miguel Almiron	24
Left Back	Christiam Pulisic	10	Left Midfield	Dwight Gayle	34
Center Midfield	Mateo Kovacic	8	Right Midfield	Allan Saint-Maximin	10
Left Wing	Romelu Lukaku	9	Right Back	Ryan Fraser	21

Chelsea vs. Leicester City

Chelsea's Squad			Leicester's Squad		
Position	Name	Number	Position	Name	Number
Goalkeeper	Edouard Mendy	16	Goalkeeper	Danny Ward	1
Left Back	Marc Cucurella	32	Right Back	Timothy Castagne	27
Center Back	Trevoh Chalobah	14	Center Back	Daniel Amartey	18
Center Back	Thiago Silva	6	Center Back	Jony Evans	6
Right Back	Reece James	24	Left Back	James Justin	2
Right Wing	Ruben Loftus-Cheek	12	Center Attack Midf	Youri Tielemans	8
Left Wing	Mason Mount	19	Center Defense Midf	Boubakary Soumare	42
Center Defense Midf	Jorginho	5	Center Attack Midf	K Dewsbury-Hall	22
Center Defense Midf	Conor Gallagher	23	Right Wing	Dennis Praet	26
Center Forward	Raheem Sterling	17	Striker	Jamie Vardy	9
Center Forward	Kai Havertz	29	Left Wing	Harvey Barnes	7
Left Wing	Cesar Azpilicueta	28	Center Defense Midf	Kelechi Iheanacho	14
Center Defense Midf	Christian Pulisic	10	Center Attack Midf	Wilfred Ndidi	25
Center Forward	Mateo Kovacic	8	Right Wing	Ayoze Perez	17
Left Back	Ben Chilwell	21			

Network Metrics for Data Analysis

Network metrics are qualitative and quantitative ways to observe and determine network behaviour.

No.	Measure	Purpose

1	Degree Centrality	○ Assigns an importance score to the players (which are represented by nodes) with the highest direct connections to other players in the same network. In other words, players with the most neighbours. This measurement can be an indication of the key players on the field as the players with the highest degree centralities (i.e., most neighbours) are likely to contribute to more passes during the game.
		○ **Implications:**
		    ○ The removal of a player with a high degree centrality will have a significant effect on the overall performance of the squad.
		    ○ The removal of a player with a low degree centrality will have little to no effect on the passing network performance.

2	Betweenness Centrality	○ Measures the extent to which a player lies on paths between other players (how much of an intermediary each player is). Using this measurement, we'd be able to identify the impact of each player as well as generalize usual betweenness centralities of certain positions in different formations.
		○ **Implications:**
		    ○ Low and evenly distributed betweenness centrality values indicate a well-balanced passing tactic. Thus, the removal of any player will have a degree of impact on the overall performance but it won't be catastrophic as everyone has a low value of betweenness so the other players would be able to make up for this loss.
		    ○ High and unevenly distributed betweenness centrality values indicate an unbalanced team (cases in which the man/star of the match is very obvious). Thus, the removal of a player with high betweenness centrality will very much destroy the team's performance as this player had considerable control over the passing between most of the other players. Whereas the removal of a player with very low betweenness centrality (ranges from 0 to 1) will have no effect whatsoever on the passing network performance because he doesn't lie on the path between any other 2 players so other players can directly pass the balls between each other without the needing this player's interference.

3	Closeness Centrality	○ Measures how close a player is to every other player in the network (i.e., on the field). In other words, how reachable a player is in the network.
		○ The difference between the betweenness centrality and the closeness centrality is that the betweenness centrality is a measure of other player's dependence on a certain player that holds an intermediary position in most of the ball passings, whereas the closeness centrality is a measure of ease of access to the player or of independence from potential control by intermediaries. Another way of reasoning it would be that betweenness doesn't measure how well-connected a player is, but rather how the ball-flow between other players depends on that particular player. Thus, it provides a measure of the impact of removing that player from the game
		○ **Implications:**
		    ○ Players with high closeness centralities have a good position in the network as they are well-connected to everyone. They will likely contribute well to the passing in the network. (Usually, midfielders)
		    ○ Players with low closeness centralities have disadvantaged positions in the network and are somewhat hard to reach by their teammates. It's unlikely that they will be able to contribute to many passes within the network of players. (Usually, players at the edge of the formation).
		    ○ If multiple people have high values of closeness centralities, then the network formation is solid and efficient because most players are positioned close to one another so the ball-passing will be a smooth process. It is no secret that tight forms often have good chemistry.

4	Average Clustering Coefficient (Transitivity)	○ This coefficient is a representative value of how tightly/closely players interact in the passing network. It measures the extent to which players tend to cluster together, because, while a network may be connected, it is possible that certain subnetworks are more strongly connected within their network than to the larger network.
		○ Each player on field has a clustering coefficient. It is the probability that a pair of other players adjacent to this player are also connected. In other words, it is the weight of triplets of nodes that are formed with the player over the total number of triplets that could possibly be formed with the player.
		○ The *average* clustering coefficient is a measurement for the entire squad calculated by taking the average of all the individual players' clustering coefficients.
		○ The clustering coefficient *distribution* is a frequency count of the occurrence of each clustering coefficient.
		○ **Implications:**
		    ○ A low clustering coefficient average is indicative of a network comprised of numerous weak ties.
		    ○ High transitivity means that the network contains communities or groups of players that are densely connected internally.

5	Graph Density	○ A measure of how many connections exist between players compared to how many connections are possible between the players. In technical terms, represents the ratio between the edges present in a graph and the maximum number of edges that the graph can contain.
		○ **Implications:**
		    ○ A dense graph is a graph in which the number of edges is close to the maximal number of edges (where every pair of players are connected). This would indicate a very high-functioning squad.
		    ○ A light graph is one where most players don't have connections which has a direct negative influence over the chemistry between the players and hinders the smoothness of the passing network.

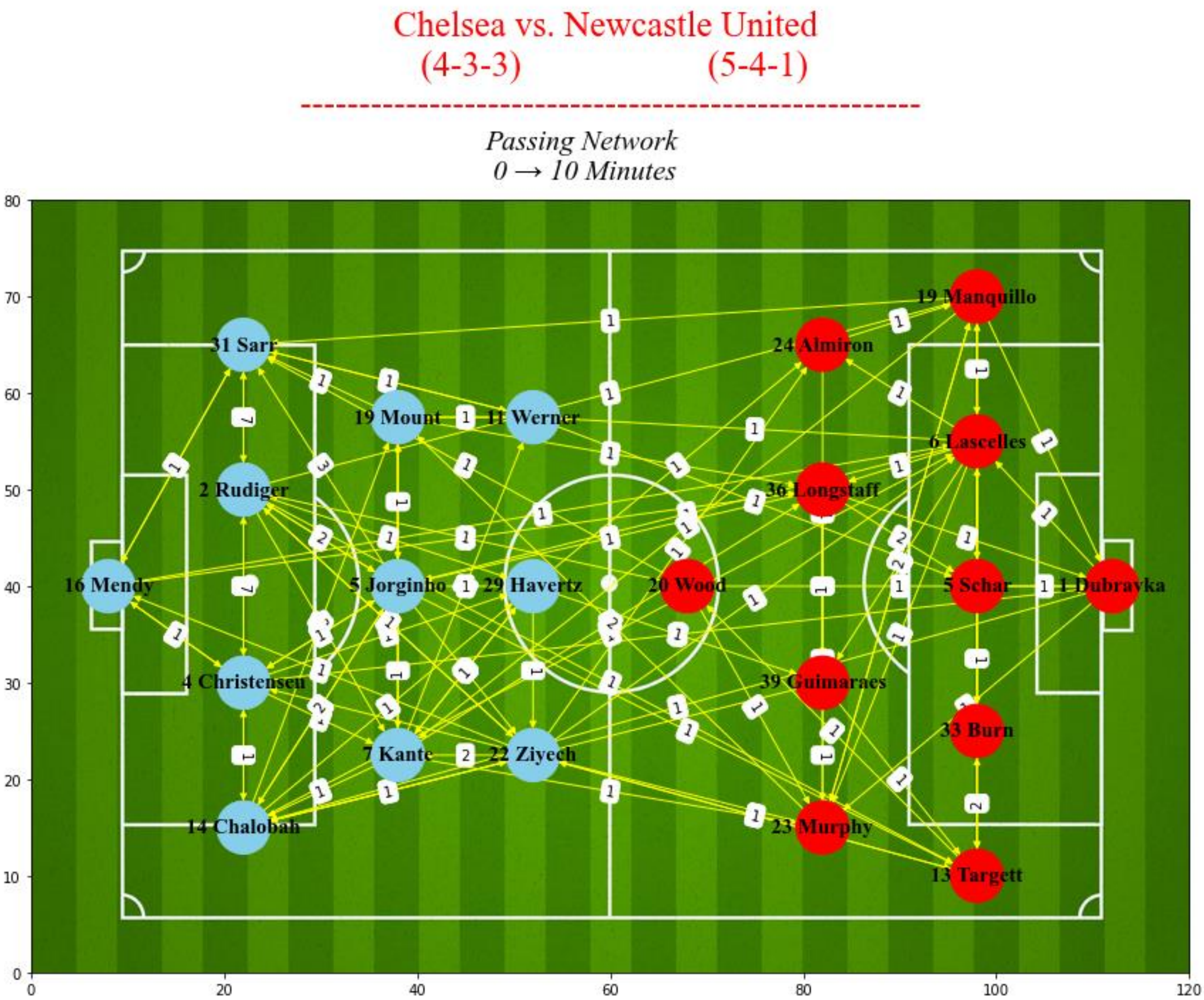
6	Ratio of Interceptions/Passes
	&
	Interceptions Graph Density
		○ Graph density is just the regular formula but applied to the section of the matrix of the interceptions.
		○ **Implications:**
		    ○ A dense graph means the team has weak ball possession.
		    ○ A light graph means the team has strong ball possession.
		○ Ratio is an originally developed formula by us that gives a value of the rate of intercepted balls to successful passes.
		○ **Implications:**
		    ○ If the value is high, it means the team has weak pall possession
		    ○ If the value is low, it means the team has strong ball possession

With this arsenal of network analysis tools, we can now begin dissecting the matches for passing data that will eventually be used in the several mathematical functions mentioned above to help us analyse the performance of the teams.

Data Analysis & Results – 1st Match

Chelsea vs. Newcastle United (March 2022)

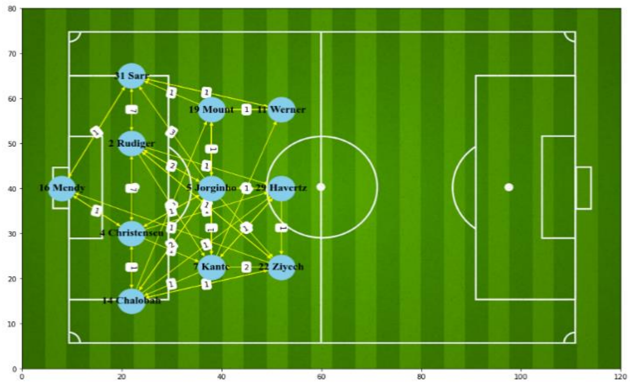
Commentary on 1st 10 Minutes



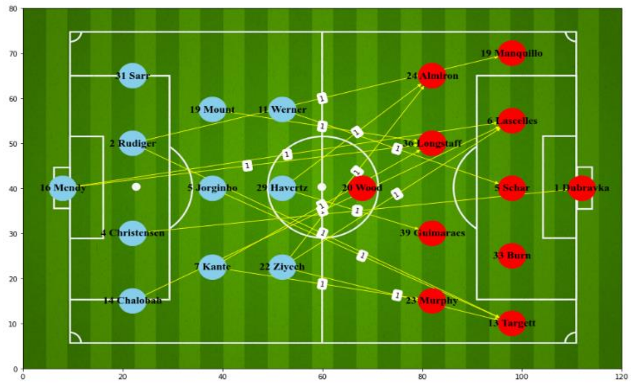
This graph here shows a complete overview of all the passes (between teammates and interceptions) that have occurred throughout the game. We have successfully managed to fix the positions of players by first displaying the x and y axis on the graph and giving them an extent (i.e., y-axis starts from 0 and ends at 80) then giving approximate points (i.e., pairs of (x, y) coordinates) on the plane as positions to each node "player". We have also coloured the nodes based on squad for a better visualization. We used the colours of their jerseys in during the game as our reference. Blue nodes are Chelsea and red nodes are Newcastle United. Newcastle wore black and white jerseys with red numbering, so that's what their colour is based on. Instead of increasing the width of the edges, resulting in an uneven and hectic graph, we have resorted to pasting the weight of the edge on it which, not only is clearer, but also is a more precise representation. We have given a title and subtitle to the graph and even set a background image to resemble the football pitch. Next plan was to represent the nodes using images of the squad's jersey, but it was a bit challenging and we were short on time.

Chelsea’s Performance (0-10 Minutes)

Chelsea Network
0 → 10 Minutes



Chelsea Got Intercepted Network
0 → 10 Minutes




```
Player:  5 Jorginho   | Degree Centrality:  12
Player:  4 Christensen   | Degree Centrality:  10
Player:  2 Rudiger   | Degree Centrality:  10
Player:  7 Kante   | Degree Centrality:  10
Player:  14 Chalobah   | Degree Centrality:  9
Player:  22 Ziyech   | Degree Centrality:  8
Player:  31 Sarr   | Degree Centrality:  8
Player:  19 Mount   | Degree Centrality:  8
Player:  29 Havertz   | Degree Centrality:  7
Player:  16 Mendy   | Degree Centrality:  5
Player:  11 Werner   | Degree Centrality:  5
```

```
Player:  5 Jorginho | Betweenness Centrality:  0.14842592592592593  | Degree:  12
Player:  2 Rudiger | Betweenness Centrality:  0.10777777777777779  | Degree:  10
Player:  7 Kante | Betweenness Centrality:  0.10592592592592592  | Degree:  10
Player:  4 Christensen | Betweenness Centrality:  0.10314814814814816  | Degree:  10
Player:  31 Sarr | Betweenness Centrality:  0.10175925925925924  | Degree:  8
Player:  19 Mount | Betweenness Centrality:  0.08101851851851852  | Degree:  8
Player:  22 Ziyech | Betweenness Centrality:  0.05175925925925926  | Degree:  8
Player:  14 Chalobah | Betweenness Centrality:  0.043888888888888894  | Degree:  9
Player:  16 Mendy | Betweenness Centrality:  0.024444444444444442  | Degree:  5
Player:  11 Werner | Betweenness Centrality:  0.01898148148148148  | Degree:  5
Player:  29 Havertz | Betweenness Centrality:  0.012870370370370369  | Degree:  7
```

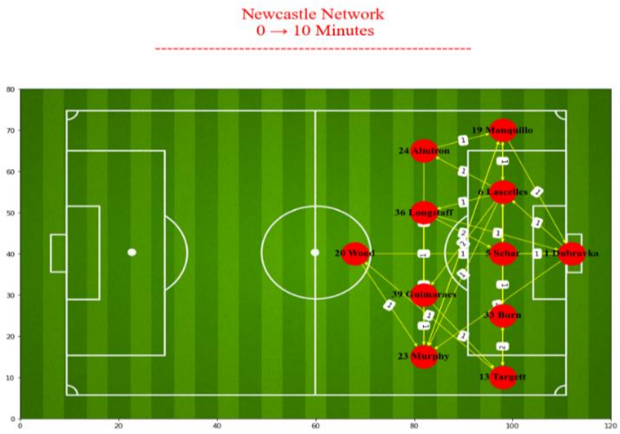
```
Player:  5 Jorginho  | Closeness Centrality:  0.7142857142857143  | Degree:  12
Player:  7 Kante  | Closeness Centrality:  0.6666666666666666  | Degree:  10
Player:  31 Sarr  | Closeness Centrality:  0.6666666666666666  | Degree:  8
Player:  2 Rudiger  | Closeness Centrality:  0.625  | Degree:  10
Player:  4 Christensen  | Closeness Centrality:  0.5882352941176471  | Degree:  10
Player:  19 Mount  | Closeness Centrality:  0.5882352941176471  | Degree:  8
Player:  29 Havertz  | Closeness Centrality:  0.5882352941176471  | Degree:  7
Player:  11 Werner  | Closeness Centrality:  0.5882352941176471  | Degree:  5
Player:  16 Mendy  | Closeness Centrality:  0.5555555555555556  | Degree:  5
Player:  14 Chalobah  | Closeness Centrality:  0.5555555555555556  | Degree:  9
Player:  22 Ziyech  | Closeness Centrality:  0.5555555555555556  | Degree:  8
```

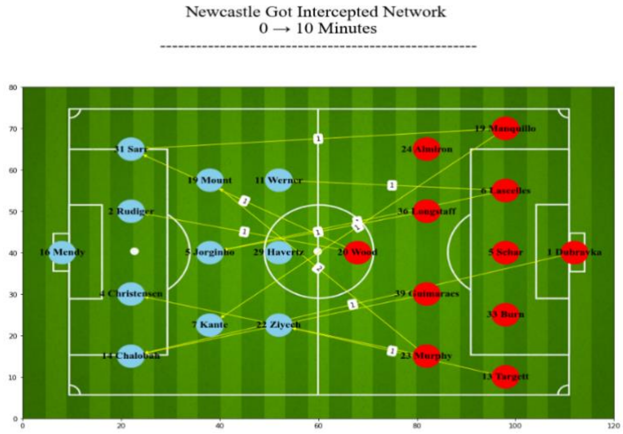
```
Player:  29 Havertz | Clustering Coefficient  0.625 | Degree:  7
Player:  11 Werner | Clustering Coefficient  0.5 | Degree:  5
Player:  14 Chalobah | Clustering Coefficient  0.48484848484848486 | Degree:  9
Player:  5 Jorginho | Clustering Coefficient  0.43548387096774194 | Degree:  12
Player:  7 Kante | Clustering Coefficient  0.4069767441860465 | Degree:  10
Player:  19 Mount | Clustering Coefficient  0.4 | Degree:  8
Player:  22 Ziyech | Clustering Coefficient  0.38461538461538464 | Degree:  8
Player:  4 Christensen | Clustering Coefficient  0.36585365853658536 | Degree:  10
Player:  2 Rudiger | Clustering Coefficient  0.36585365853658536 | Degree:  10
Player:  31 Sarr | Clustering Coefficient  0.2 | Degree:  8
Player:  16 Mendy | Clustering Coefficient  0 | Degree:  5
```

Passing Network Density = 0.41818181818181815
Global Average Clustering Coefficient = 0.378966527426439
Interception Network Density = 0.03463203463203463
Sum of successful passes = 75
Sum of interceptions = 16
Interception Ratio = 16 / 75 = 0.21333333333333335

During the 1st 10 minutes of the match, we can observe player Jorginho has proven himself to be a key player in the game, having the highest degree centrality, betweenness centrality, and closeness centrality. This means that he has a significant effect on the passing of the ball in Chelsea’s network and it also means that he has a good position on the pitch. Consequently, if Jorginho were to be removed from the network, it would have a significant effect on the chemistry and effectiveness of the passing network of Chelsea. All of this makes sense as Jorginho has been playing as Center Midfielder which is a position close to every other player. If anything, his very function is to connect other nodes to one another (i.e., pass the ball from the back to the front, etc…). From the closeness centrality results, we can see that the values are almost equal and evenly distributed. This means there is a good balance in the positioning of each player on the field. In the clustering coefficient, we can see player Mendy has a value of 0 which makes sense as he is the goalkeeper, and he doesn’t get passed the ball often. The fact that player Havertz is on top of the clustering coefficient table means that he has a strong connection with most players which is indicative of the fact that the team passes him the ball often as he is the Center Forward position who is supposed to initiate attacks. In the degree centrality we can observe that the player Werner is at the bottom of the table with a degree of 5 only. This means that removing him from the squad won’t have much significant effect on the harmony of the network. As a matter of fact, he has been substituted by Lukaku in the 2nd half of the game. The interception network density value is very low which indicates that the team has good ball possession. The passing network density value is much higher in comparison which means that the team is functioning effectively. The ratio of interceptions to passes is very low which indicates that the team has much more successful passes than intercepted balls.

Newcastle's Performance (0-10 Minutes)





Player	Degree Centrality
6 Lascelles	9
19 Manquillo	7
23 Murphy	7
1 Dubravka	6
36 Longstaff	6
39 Guimaraes	6
5 Schar	5
33 Burn	5
13 Targett	5
20 Wood	3
24 Almiron	3

Player	Betweenness Centrality	Degree
6 Lascelles	0.30666666666666664	9
23 Murphy	0.19518518518518518	7
19 Manquillo	0.1896296296296296	7
36 Longstaff	0.1648148148148148	6
1 Dubravka	0.10629629629629629	6
33 Burn	0.07814814814814815	5
39 Guimaraes	0.06481481481481481	6
13 Targett	0.061111111111111	5
5 Schar	0.046296296296296294	5
20 Wood	0.04259259259259259	3
24 Almiron	0.011111111111111112	3

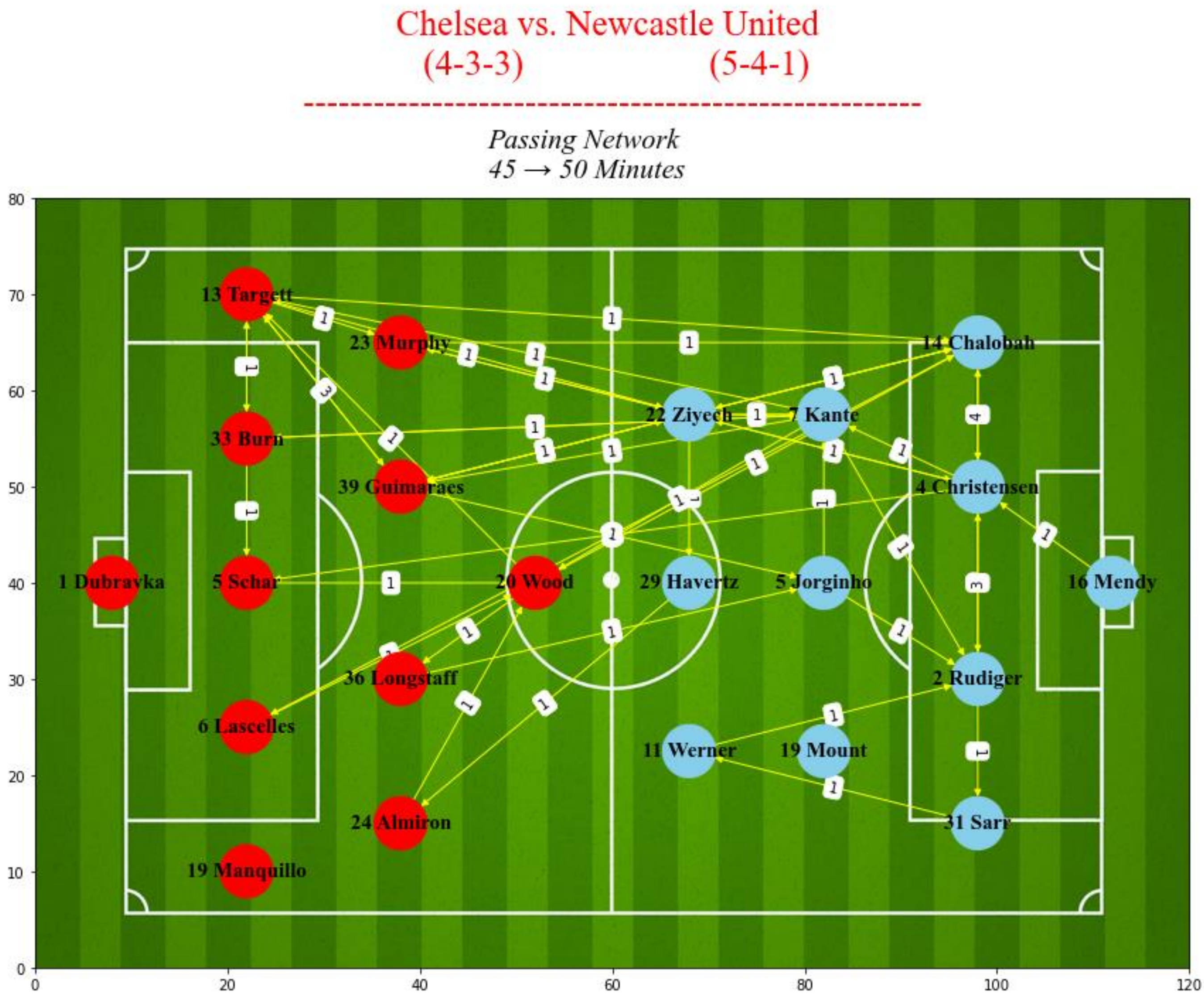
Player	Closeness Centrality	Degree
23 Murphy	0.6666666666666666	7
6 Lascelles	0.5263157894736842	9
19 Manquillo	0.5263157894736842	7
36 Longstaff	0.5263157894736842	6
39 Guimaraes	0.5	6
13 Targett	0.5	5
20 Wood	0.5	3
1 Dubravka	0.47619047619047616	6
33 Burn	0.47619047619047616	5
5 Schar	0.43478260869565216	5
24 Almiron	0.37037037037037035	3

Player	Clustering Coefficient	Degree
1 Dubravka	0.3333333333333333	6
24 Almiron	0.3333333333333333	3
36 Longstaff	0.2857142857142857	6
13 Targett	0.2777777777777778	5
23 Murphy	0.275	7
33 Burn	0.25	5
39 Guimaraes	0.25	6
6 Lascelles	0.22857142857142856	9
19 Manquillo	0.21052631578947367	7
5 Schar	0.16666666666666666	5
20 Wood	0.16666666666666666	3

Passing Network Density = 0.2818181818181818
Global Average Clustering Coefficient = 0.25250816435026957
Interception Network Density = 0.025974025974025976
Sum of successful passes = 38
Sum of interceptions = 13
Interception Ratio = 13 / 38 = 0.34210526315789475

During the 1st 10 minutes of the match, we can observe player Lascelles has the highest degree centrality and betweenness centrality, he also ranks the 2nd in the closeness centrality. We can start making sense of the relations between those measures, they're almost proportionally related and here's how: When a players has a high closeness centrality, it means he has a good position with relation to reachability of each other node, and since he is close to almost every other node, then he must be on the way from one node to another (i.e., he is between them as the linking player) and so since has a high betweenness then he is contribution to the passing of the ball from many players to many other players which means his degree (in and out) will be high! This means that Lascelles has been a key player in the ball passing, however, observing the degree centrality table as a whole, we can see that the numbers, although low, are quite evenly distributed. So, most players in the team had a significant contribution. Another proof of this hypothesis (of proportional relation between the centrality measures) is player Almiron who is found at the bottom of all 3 of the centrality measures tables. From the closeness centrality table, we can see that player Almiron was placed at quite the disadvantaged position which also affected his betweenness centrality value and, consequently, his degree centrality. The fact that player Dubravka, Newcastle's goalkeeper, has the highest clustering coefficient indicates that the team has been playing defensively in their own half. Furthermore, the low ranks of player Wood (The team's striker) in the centrality measures further support the fact that the team has been playing defensively as he has 0.1 clustering coefficient even though his closeness centrality is good enough. The network density value is quite low at 0.2 which tells that the team had weak ball possession. The interception network density is a low value but that is because Newcastle did not possess the ball much to begin with, so as they have low ball possession, then, surely, they have low interception rate since they didn't have the ball for it to be taken from them. We have a higher ratio of interceptions/passes than Chelsea's, this is because the passes are few and the interceptions are also few. Finally, the average clustering coefficient value is 0.2 which is very low and indicates that the team has overall weak ties.

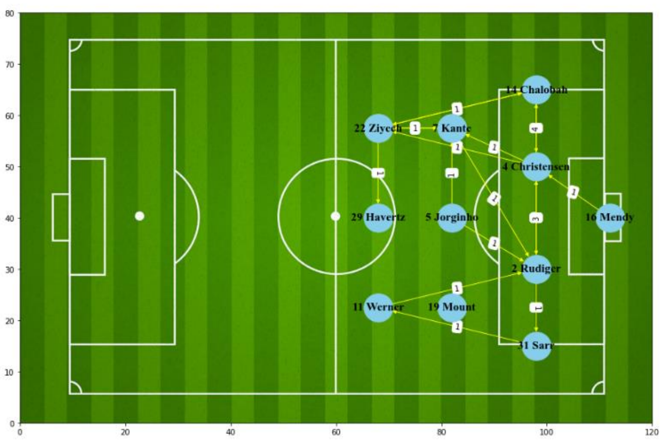
Commentary on Beginning of 2nd Half (45 – 50 Minutes)



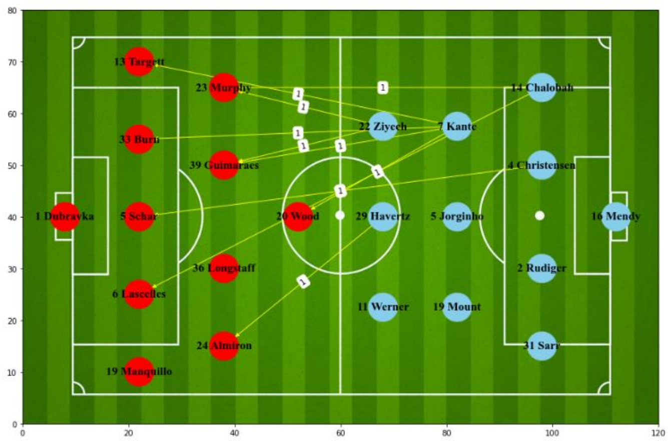
We can notice from the graph how the players have switched places on the field. We can also observe that no substitutions happened yet. Comparing this network to the previous one, we can see less density in the edges which is usually natural behaviour as players are most energized and contributing at the beginning of the match. Looking at the network overall, we can see the most contributing players are Chalobah, Targett, and Kante. Even though player Targett is not at the most advantaged position on the pitch, he evidently proved himself to be a dynamic player able to add value to the game wherever he is standing, and no matter how low his closeness centrality is. From this graph we can also note that Chelsea is a high-functioning team as every player has at least 2 edges (one in and one out) and all are showing real talent and effort regardless of their positions on the field. From this overall view, everyone seems to be fulfilling their assigned role. Although it can be seen that Werner, a left winger who should be initiating attacks did not get the ball much and the one time he got the ball he returned it back to the midfield. Havertz tried to initiate an attack that was eventually intercepted by player Almiron and Ziyech, the right winger seemed to be the most contributing of the 3 front players. From the formations of both teams (which hasn't changed from the 1st half), we can see Newcastle sticking to their defensive standing with 5 players in the backfield supported by 4 in the midfield and only one striker at the front. So, we can observe a very goal-guarding approach and it may be intimidation from Chelsea's skill. Chelsea, on the other hand, is taking a very balanced formation. 3 front, 3 in the middle, 4 at the back. Compact and well-distributed making for equal chances at initiating strikes or defending.

Chelsea’s Performance (45 – 50 Minutes)

Chelsea Network
45 → 50 Minutes



Chelsea Got Intercepted Network
45 → 50 Minutes




```
Player:  4 Christensen  | Degree Centrality:  7
Player:  2 Rudiger  | Degree Centrality:  6
Player:  22 Ziyech  | Degree Centrality:  6
Player:  7 Kante  | Degree Centrality:  5
Player:  14 Chalobah  | Degree Centrality:  4
Player:  5 Jorginho  | Degree Centrality:  2
Player:  31 Sarr  | Degree Centrality:  2
Player:  11 Werner  | Degree Centrality:  2
Player:  16 Mendy  | Degree Centrality:  1
Player:  29 Havertz  | Degree Centrality:  1
Player:  19 Mount  | Degree Centrality:  0
```

```
Player:  2 Rudiger | Betweenness Centrality:  0.2833333333333333  | Degree:  6
Player:  4 Christensen | Betweenness Centrality:  0.25555555555555556  | Degree:  7
Player:  22 Ziyech | Betweenness Centrality:  0.11111111111111112  | Degree:  6
Player:  31 Sarr | Betweenness Centrality:  0.07777777777777778  | Degree:  2
Player:  11 Werner | Betweenness Centrality:  0.06666666666666667  | Degree:  2
Player:  7 Kante | Betweenness Centrality:  0.061111111111111116  | Degree:  5
Player:  14 Chalobah | Betweenness Centrality:  0.011111111111111112  | Degree:  4
Player:  16 Mendy | Betweenness Centrality:  0.0  | Degree:  1
Player:  5 Jorginho | Betweenness Centrality:  0.0  | Degree:  2
Player:  19 Mount | Betweenness Centrality:  0.0  | Degree:  0
Player:  29 Havertz | Betweenness Centrality:  0.0  | Degree:  1
```

```
Player:  2 Rudiger  | Closeness Centrality:  0.5333333333333333  | Degree:  6
Player:  4 Christensen  | Closeness Centrality:  0.45714285714285713  | Degree:  7
Player:  22 Ziyech  | Closeness Centrality:  0.4  | Degree:  6
Player:  7 Kante  | Closeness Centrality:  0.4  | Degree:  5
Player:  14 Chalobah  | Closeness Centrality:  0.35555555555555557  | Degree:  4
Player:  31 Sarr  | Closeness Centrality:  0.35555555555555557  | Degree:  2
Player:  29 Havertz  | Closeness Centrality:  0.324  | Degree:  1
Player:  11 Werner  | Closeness Centrality:  0.26666666666666666  | Degree:  2
Player:  16 Mendy  | Closeness Centrality:  0.0  | Degree:  1
Player:  5 Jorginho  | Closeness Centrality:  0.0  | Degree:  2
Player:  19 Mount  | Closeness Centrality:  0.0  | Degree:  0
```

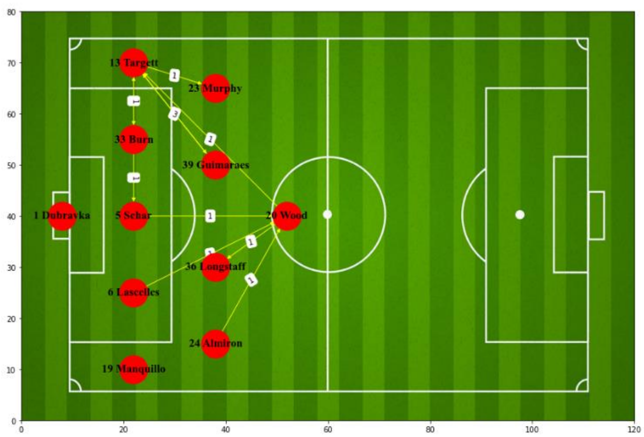
```
Player:  14 Chalobah | Clustering Coefficient  0.5 | Degree:  4
Player:  5 Jorginho | Clustering Coefficient  0.5 | Degree:  2
Player:  31 Sarr | Clustering Coefficient  0.5 | Degree:  2
Player:  11 Werner | Clustering Coefficient  0.5 | Degree:  2
Player:  7 Kante | Clustering Coefficient  0.2777777777777778 | Degree:  5
Player:  22 Ziyech | Clustering Coefficient  0.23076923076923078 | Degree:  6
Player:  4 Christensen | Clustering Coefficient  0.21052631578947367 | Degree:  7
Player:  2 Rudiger | Clustering Coefficient  0.14285714285714285 | Degree:  6
Player:  16 Mendy | Clustering Coefficient  0 | Degree:  1
Player:  19 Mount | Clustering Coefficient  0 | Degree:  0
Player:  29 Havertz | Clustering Coefficient  0 | Degree:  1
```

Passing Network Density = 0.16363636363636364
Global Average Clustering Coefficient = 0.2601754970176023
Interception Network Density = 0.021645021645021644
Sum of successful passes = 28
Sum of interceptions = 10
Interception Ratio = 10 / 28 = 0.35714285714285715

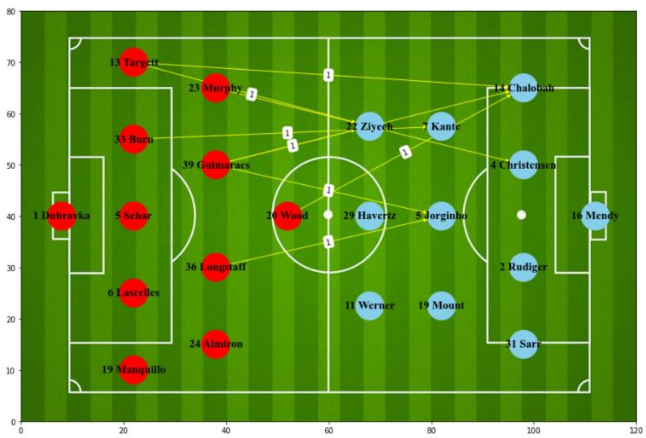
We can see that, during this time interval, Chelsea’s player Jorginho has dropped low on the centrality measures, remaining high only in the clustering coefficient. In his place are Christensen and Rudiger who have become the key players in the passing network. We can also note the complete lack of contribution of some players such as Mount, Mendy, and Havertz. This tells us that Chelsea haven’t tried to initiate any attacks at the beginning of the 2nd half, nor did Newcastle with the proof that Mendy is not contributing to the game. We can sense that the players have just been passing the ball around looking for a chance and building up heat for the rest of the match. The passing network density has dropped from 0.4 to 0.1. As for the interception network density it is almost the exact same. We can observe from the interception network graph that player Kante has been the one to get intercepted the most and that is because he was helping with initiating attacks most of the time. Murphy and Guimaraes are the two Newcastle players who contributed the most in intercepting the ball from Chelsea. 28 successful passes seem a bit weak in the span of 10 minutes especially considering that Chelsea has been able to achieve 75 successful passes in the first 10 minutes of the match’s beginning. Once again, when Christensen and Rudiger rose to the top of the tables, they rose in all the 3 centrality tables, further proving that centrality measures are proportionally related to one another.

Newcastle’s Performance (45 – 50 Minutes)

Newcastle Network
45 → 50 Minutes



Newcastle Got Intercepted Network
45 → 50 Minutes




```
Player:  13 Targett   | Degree Centrality:  6
Player:  20 Wood   | Degree Centrality:  5
Player:  33 Burn   | Degree Centrality:  3
Player:  5 Schar   | Degree Centrality:  2
Player:  39 Guimaraes   | Degree Centrality:  2
Player:  6 Lascelles   | Degree Centrality:  1
Player:  36 Longstaff   | Degree Centrality:  1
Player:  23 Murphy   | Degree Centrality:  1
Player:  24 Almiron   | Degree Centrality:  1
Player:  1 Dubravka   | Degree Centrality:  0
Player:  19 Manquillo   | Degree Centrality:  0
```

```
Player:  13 Targett | Betweenness Centrality:  0.24444444444444446  | Degree:  6
Player:  20 Wood | Betweenness Centrality:  0.22222222222222224  | Degree:  5
Player:  33 Burn | Betweenness Centrality:  0.1  | Degree:  3
Player:  5 Schar | Betweenness Centrality:  0.06666666666666667  | Degree:  2
Player:  1 Dubravka | Betweenness Centrality:  0.0  | Degree:  0
Player:  6 Lascelles | Betweenness Centrality:  0.0  | Degree:  1
Player:  19 Manquillo | Betweenness Centrality:  0.0  | Degree:  0
Player:  36 Longstaff | Betweenness Centrality:  0.0  | Degree:  1
Player:  39 Guimaraes | Betweenness Centrality:  0.0  | Degree:  2
Player:  23 Murphy | Betweenness Centrality:  0.0  | Degree:  1
Player:  24 Almiron | Betweenness Centrality:  0.0  | Degree:  1
```

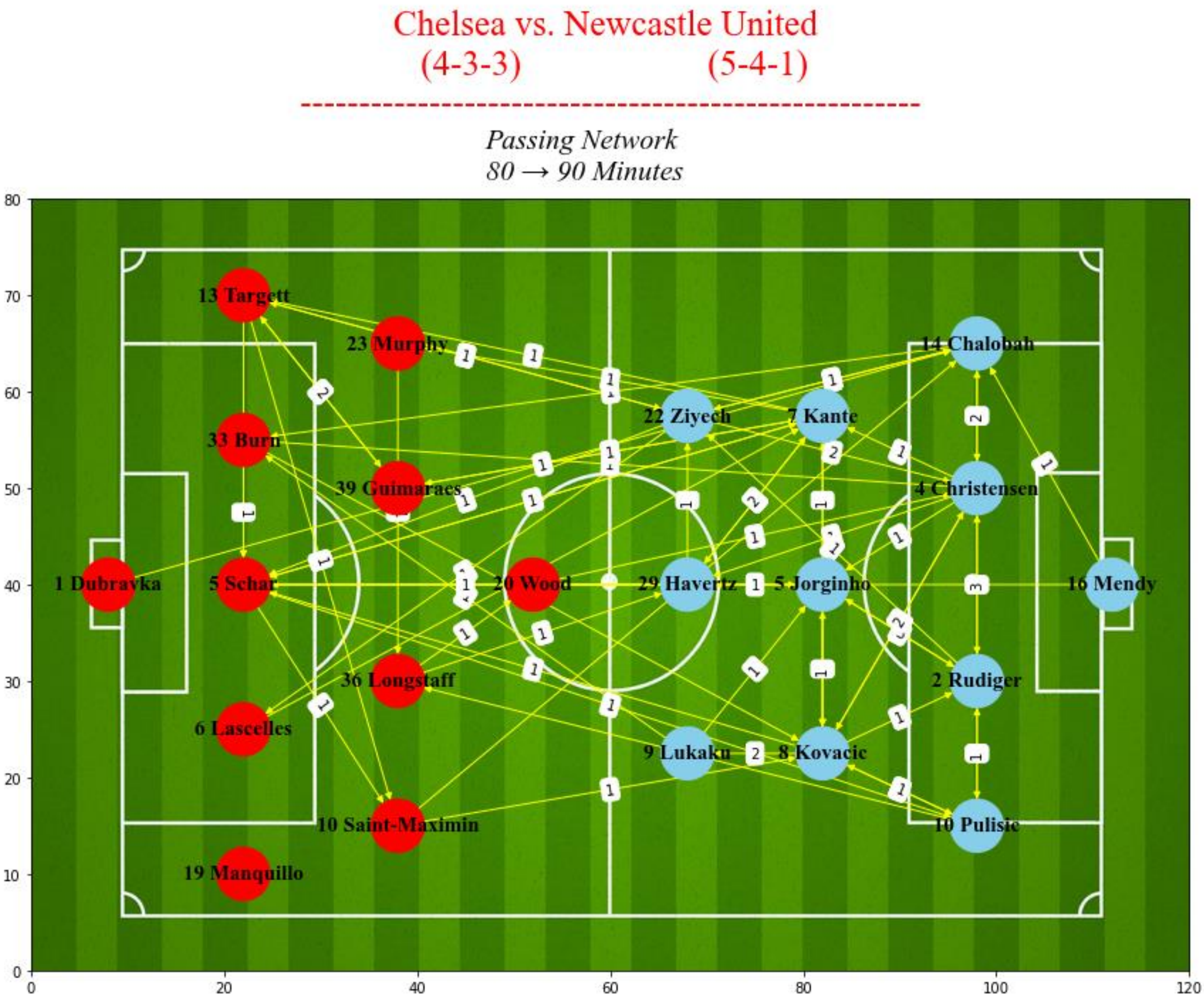
```
Player:  13 Targett  | Closeness Centrality:  0.39999999999999997  | Degree:  6
Player:  23 Murphy  | Closeness Centrality:  0.30624999999999997  | Degree:  1
Player:  20 Wood  | Closeness Centrality:  0.3  | Degree:  5
Player:  36 Longstaff  | Closeness Centrality:  0.25789473684210523  | Degree:  1
Player:  33 Burn  | Closeness Centrality:  0.2571428571428571  | Degree:  3
Player:  39 Guimaraes  | Closeness Centrality:  0.2571428571428571  | Degree:  2
Player:  5 Schar  | Closeness Centrality:  0.21176470588235294  | Degree:  2
Player:  1 Dubravka  | Closeness Centrality:  0.0  | Degree:  0
Player:  6 Lascelles  | Closeness Centrality:  0.0  | Degree:  1
Player:  19 Manquillo  | Closeness Centrality:  0.0  | Degree:  0
Player:  24 Almiron  | Closeness Centrality:  0.0  | Degree:  1
```

```
Player:  1 Dubravka | Clustering Coefficient  0 | Degree:  0
Player:  5 Schar | Clustering Coefficient  0 | Degree:  2
Player:  6 Lascelles | Clustering Coefficient  0 | Degree:  1
Player:  33 Burn | Clustering Coefficient  0 | Degree:  3
Player:  19 Manquillo | Clustering Coefficient  0 | Degree:  0
Player:  36 Longstaff | Clustering Coefficient  0 | Degree:  1
Player:  39 Guimaraes | Clustering Coefficient  0 | Degree:  2
Player:  13 Targett | Clustering Coefficient  0 | Degree:  6
Player:  23 Murphy | Clustering Coefficient  0 | Degree:  1
Player:  20 Wood | Clustering Coefficient  0 | Degree:  5
Player:  24 Almiron | Clustering Coefficient  0 | Degree:  1
```

Passing Network Density = 0.1
Global Average Clustering Coefficient = 0.0
Interception Network Density = 0.01948051948051948
Sum of successful passes = 13
Sum of interceptions = 9
Interception Ratio = 9 / 13 = 0.6923076923076923

Targett and Wood dominate the top of the centrality measures tables although their values are considerably low, they are the ones most proactive. Of significance is how all the players have a clustering coefficient of 0, making a global clustering coefficient of 0. This denotes weak ties between the players, and this is further proved by the 0.1 very low passing network density. Having a total of 13 successful passes in 10 whole minutes is a bad presentation of the team’s skill and thus their network efficiency. The interception ratio is quite high as 0.69 almost 0.7, the teams balls were intercepted almost as much as they made successful passes. These statistics give a very good indication of the likelihood of Newcastle substitutions occurring in the rest of the match as an attempt from Newcastle’s manager to try and flip the match around and get some game going since, so far, this team compilation seems to be no match for Chelsea even though both teams dropped in performance at the start of the 2nd half, Chelsea was still in a better shape. Players that are good candidates for substitutions are Almiron and Manquillo who have repeatedly appeared at the bottom of the performance measures tables. It takes only one correct change to a correct player in the midfield to fix a whole team, but will Newcastle be able to find a good fit?

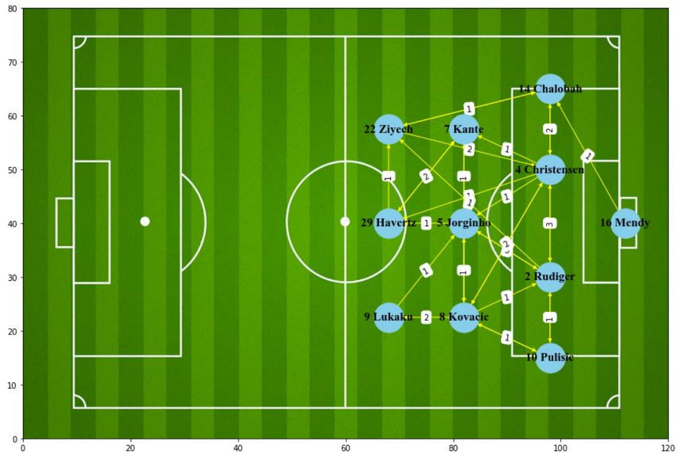
Commentary on Last 10 Minutes (80 – 90 Minutes)



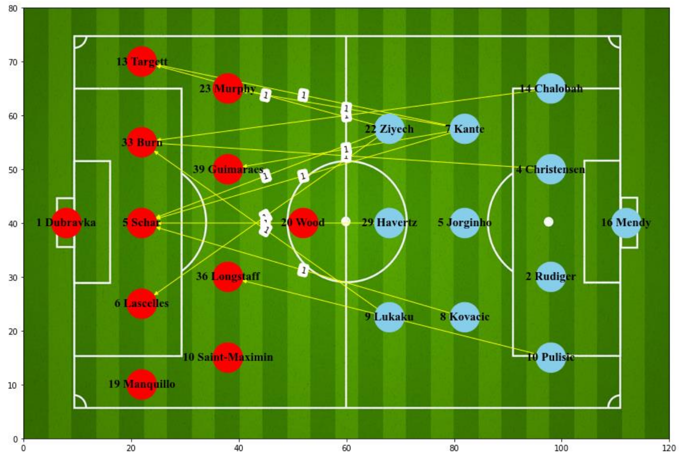
This graph gives us a visual indicator that both teams are now trying to cease the chance and either flip the game around (in the case of Newcastle) or preserve their very close win (in the case of Chelsea, who have scored a goal in the devastating last 10 minutes by Havertz with an assist from Jorginho). The many edges show the fervent pressure both teams are applying. Also, we will observe how the substitution of Chelsea's Mount with Kovacic and Werner by Lukaku and Newcastle's Almiron with Saint-Maximin has revived the game's overall network. Noteworthy is that both teams' substitutions seem to be educated decisions as they are statistically the correct moves as we've noted Almiron, Werner, and Mount to be a weakly-contributing players in the previously discussed time intervals. Having a long look at the formation of edges for each of the teams, one can see a well-connected and efficient network, much more balanced and aesthetically pleasing than Newcastle's.

Chelsea's Performance (80 – 90 Minutes)

Chelsea Network
80 → 90 Minutes



Chelsea Got Intercepted Network
80 → 90 Minutes



Player: 4 Christensen | Degree Centrality: 10
Player: 8 Kovacic | Degree Centrality: 9
Player: 2 Rudiger | Degree Centrality: 8
Player: 5 Jorginho | Degree Centrality: 8
Player: 14 Chalobah | Degree Centrality: 5
Player: 22 Ziyech | Degree Centrality: 5
Player: 7 Kante | Degree Centrality: 5
Player: 29 Havertz | Degree Centrality: 5
Player: 10 Pulisic | Degree Centrality: 4
Player: 9 Lukaku | Degree Centrality: 2
Player: 16 Mendy | Degree Centrality: 1

Player: 4 Christensen | Betweenness Centrality: 0.32592592592592595 | Degree: 10
Player: 8 Kovacic | Betweenness Centrality: 0.24814814814814815 | Degree: 9
Player: 5 Jorginho | Betweenness Centrality: 0.12962962962962962 | Degree: 8
Player: 2 Rudiger | Betweenness Centrality: 0.12222222222222223 | Degree: 8
Player: 14 Chalobah | Betweenness Centrality: 0.10370370370370371 | Degree: 5
Player: 22 Ziyech | Betweenness Centrality: 0.05925925925925926 | Degree: 5
Player: 7 Kante | Betweenness Centrality: 0.044444444444444446 | Degree: 5
Player: 29 Havertz | Betweenness Centrality: 0.037037037037037035 | Degree: 5
Player: 10 Pulisic | Betweenness Centrality: 0.007407407407407408 | Degree: 4
Player: 16 Mendy | Betweenness Centrality: 0.0 | Degree: 1
Player: 9 Lukaku | Betweenness Centrality: 0.0 | Degree: 2

Player: 4 Christensen | Closeness Centrality: 0.5882352941176471 | Degree: 10
Player: 8 Kovacic | Closeness Centrality: 0.5882352941176471 | Degree: 9
Player: 2 Rudiger | Closeness Centrality: 0.5555555555555556 | Degree: 8
Player: 22 Ziyech | Closeness Centrality: 0.5555555555555556 | Degree: 5
Player: 5 Jorginho | Closeness Centrality: 0.5555555555555556 | Degree: 8
Player: 7 Kante | Closeness Centrality: 0.5263157894736842 | Degree: 5
Player: 29 Havertz | Closeness Centrality: 0.5263157894736842 | Degree: 5
Player: 14 Chalobah | Closeness Centrality: 0.45454545454545453 | Degree: 5
Player: 10 Pulisic | Closeness Centrality: 0.4166666666666667 | Degree: 4
Player: 9 Lukaku | Closeness Centrality: 0.4 | Degree: 2
Player: 16 Mendy | Closeness Centrality: 0.0 | Degree: 1

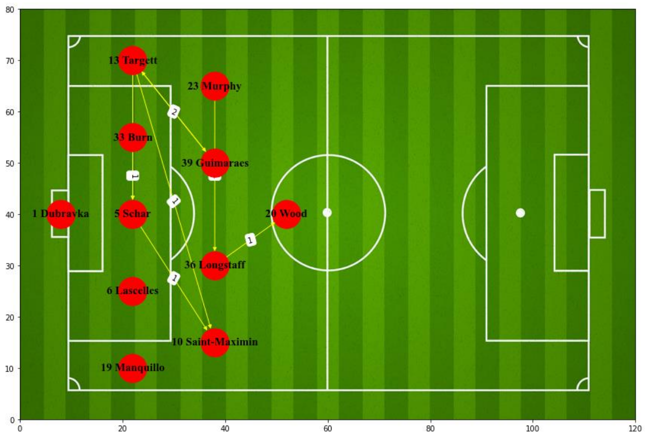
Player: 9 Lukaku | Clustering Coefficient 1.0 | Degree: 2
Player: 7 Kante | Clustering Coefficient 0.5 | Degree: 5
Player: 10 Pulisic | Clustering Coefficient 0.5 | Degree: 4
Player: 22 Ziyech | Clustering Coefficient 0.3888888888888889 | Degree: 5
Player: 5 Jorginho | Clustering Coefficient 0.38461538461538464 | Degree: 8
Player: 2 Rudiger | Clustering Coefficient 0.36 | Degree: 8
Player: 8 Kovacic | Clustering Coefficient 0.3333333333333333 | Degree: 9
Player: 29 Havertz | Clustering Coefficient 0.3333333333333333 | Degree: 5
Player: 4 Christensen | Clustering Coefficient 0.2976190476190476 | Degree: 10
Player: 14 Chalobah | Clustering Coefficient 0.25 | Degree: 5
Player: 16 Mendy | Clustering Coefficient 0 | Degree: 1

Passing Network Density = 0.2818181818181818
Global Average Clustering Coefficient = 0.39525363525363527
Interception Network Density = 0.02813852813852814
Sum of successful = 47
Sum of interceptions = 13
Interception Ratio = 13 / 47 = 0.2765957446808511

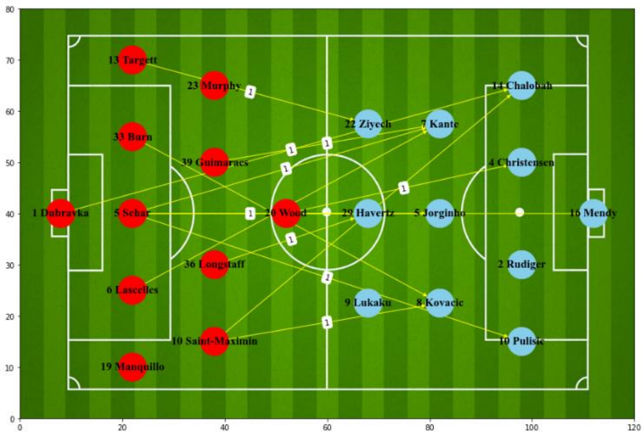
The sum of successful passes has increased from 28 to 47. Still not the standard Chelsea has set at the beginning of the game, but it still shows that the correct substitution decisions were made to increase the efficiency of the network. The interception ratio is very low at 0.2, meaning that Chelsea has been skilful at keeping the ball for most of the time. We can see that player Kovacic, Mount's substitute has placed himself high in the centrality measures, a closeness centrality that is balanced and in-sync with the entire team (except for Mendy, since he's the goalkeeper). Kovacic's degree centrality is also very high, coming right after Christensen who continues to be at the top of the chart. Although the team's centre forward scores consistently medium to low on all the measures, when presented with the chance, he has seized it and scored a goal with the help of the midfielder Jorginho who is climbing his way back up the performance measures. Also, player Pulisic has been a substitute for Sarr, although this change did not make much difference at all. He gave almost the same performance, ranking a bit low in the centrality tables. The clustering coefficient is not high, but it is improving from the last analysis to almost the double (from 0.2 to 0.39).

Newcastle's Performance (80 – 90 Minutes)

Newcastle Network
80 → 90 Minutes



Newcastle Got Intercepted Network
80 → 90 Minutes




```
Player:  13 Targett   | Degree Centrality:  4
Player:  5 Schar   | Degree Centrality:  3
Player:  36 Longstaff   | Degree Centrality:  2
Player:  39 Guimaraes   | Degree Centrality:  2
Player:  10 Saint-Maximin   | Degree Centrality:  2
Player:  33 Burn   | Degree Centrality:  1
Player:  23 Murphy   | Degree Centrality:  1
Player:  20 Wood   | Degree Centrality:  1
Player:  1 Dubravka   | Degree Centrality:  0
Player:  6 Lascelles   | Degree Centrality:  0
Player:  19 Manquillo   | Degree Centrality:  0
```

```
Player:  13 Targett | Betweenness Centrality:  0.022222222222222223  | Degree:  4
Player:  5 Schar | Betweenness Centrality:  0.011111111111111112  | Degree:  3
Player:  36 Longstaff | Betweenness Centrality:  0.011111111111111112  | Degree:  2
Player:  1 Dubravka | Betweenness Centrality:  0.0  | Degree:  0
Player:  6 Lascelles | Betweenness Centrality:  0.0  | Degree:  0
Player:  33 Burn | Betweenness Centrality:  0.0  | Degree:  1
Player:  19 Manquillo | Betweenness Centrality:  0.0  | Degree:  0
Player:  39 Guimaraes | Betweenness Centrality:  0.0  | Degree:  2
Player:  23 Murphy | Betweenness Centrality:  0.0  | Degree:  1
Player:  20 Wood | Betweenness Centrality:  0.0  | Degree:  1
Player:  10 Saint-Maximin | Betweenness Centrality:  0.0  | Degree:  2
```

```
Player:  10 Saint-Maximin  | Closeness Centrality:  0.26666666666666666  | Degree:  2
Player:  5 Schar  | Closeness Centrality:  0.22499999999999998  | Degree:  3
Player:  20 Wood  | Closeness Centrality:  0.13333333333333333  | Degree:  1
Player:  36 Longstaff  | Closeness Centrality:  0.1  | Degree:  2
Player:  39 Guimaraes  | Closeness Centrality:  0.1  | Degree:  2
Player:  13 Targett  | Closeness Centrality:  0.1  | Degree:  4
Player:  1 Dubravka  | Closeness Centrality:  0.0  | Degree:  0
Player:  6 Lascelles  | Closeness Centrality:  0.0  | Degree:  0
Player:  33 Burn  | Closeness Centrality:  0.0  | Degree:  1
Player:  19 Manquillo  | Closeness Centrality:  0.0  | Degree:  0
Player:  23 Murphy  | Closeness Centrality:  0.0  | Degree:  1
```

```
Player:  10 Saint-Maximin | Clustering Coefficient  0.5 | Degree:  2
Player:  5 Schar | Clustering Coefficient  0.16666666666666666 | Degree:  3
Player:  13 Targett | Clustering Coefficient  0.1 | Degree:  4
Player:  1 Dubravka | Clustering Coefficient  0 | Degree:  0
Player:  6 Lascelles | Clustering Coefficient  0 | Degree:  0
Player:  33 Burn | Clustering Coefficient  0 | Degree:  1
Player:  19 Manquillo | Clustering Coefficient  0 | Degree:  0
Player:  36 Longstaff | Clustering Coefficient  0 | Degree:  2
Player:  39 Guimaraes | Clustering Coefficient  0 | Degree:  2
Player:  23 Murphy | Clustering Coefficient  0 | Degree:  1
Player:  20 Wood | Clustering Coefficient  0 | Degree:  1
```

Passing Network Density = 0.07272727272727272
Global Average Clustering Coefficient = 0.06969696969696969
Interception Network Density = 0.030303030303030304
Sum of successful passes = 10
Sum of interceptions = 14
Interception Ratio = 14 / 10 = 1.4

Based on the degree centrality table, Targett seems to still be Newcastle's key player along with the defenders Schar and Longstaff. However, there are multiple concerning things to note about the network state during this time interval. Firstly, the closeness centrality is not at all balanced with 5 players having a value of 0. As for the clustering coefficient, 8 players have 8, which indicates that most of the network is not comprised of any sort of ties. Only Saint-Maximin has a considerable clustering coefficient. The number of successful passes has dropped even lower from the previously discussed time interval (from 13 to 10), not only that, but the total interceptions both increased from 9 to 14 and is greater than the sum of successful passes. Which such a high value of interception ratio, this can officially and statistically be labelled a weak/failed network. The passing network density is so low as 0.07. Player Manquillo is evidently not contributing to the network. His degree centrality, betweenness centrality, closeness centrality, and clustering coefficient evaluating to 0. A perfect candidate for a substitution, although it is a bit late, but, in fact, during the 4-minute overtime period, he was changed for Fraser who did not have much time to make any sort of significant impact.

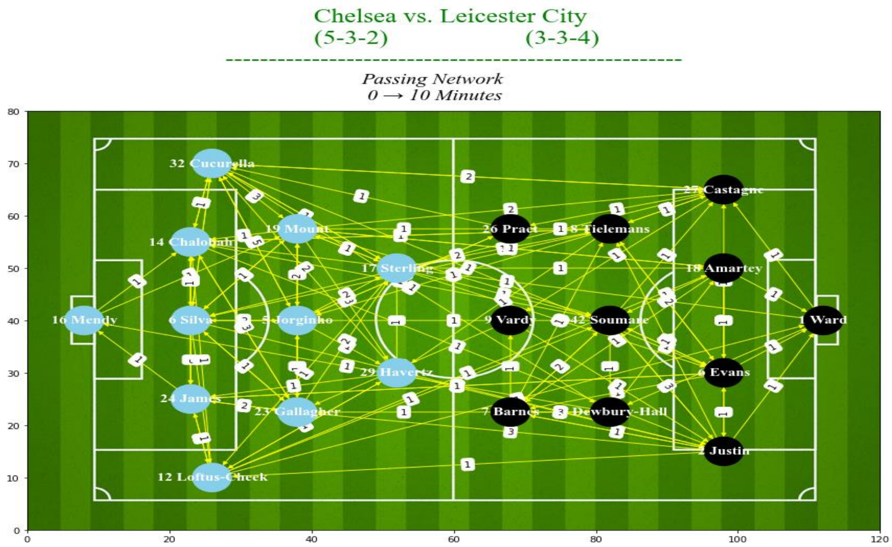
Finally ...

Chelsea's overall network evolution over time can be summed up as follows: The players with the highest degree centralities in all of the 3 discussed time intervals had degree centralities of 12 to 7 to 10 in their respective order. The numbers being in the same range shows the consistent effort of the overall team and the efficiency of the network. Regardless of the significant changes in the number of passes between each time interval, they have been able to maintain a steady highest degree centrality. Those degree centralities have been achieved by Jorginho and Christensen. The team's balanced formation is a major factor in its consistent performance. Having almost the same number of players at every part of the field (front, middle, and back) makes the team a jack of all trades; able to dynamically change tactic from attacking to defending when the need arises. Chelsea's formation also positively affected the team's interaction as a network; making it compact and well-connected as has been illustrated in the previously provided graphs of Chelsea's network. The goalkeeper Mendy often ranked low on all the charts which proves that the team was attacking more than it was defending or stalling. Key players in Chelsea were Jorginho (not only ranking high in the centralities charts but also giving assist to the match's single goal), Christensen, Rudiger, and Ziyech. From this we can determine some characteristics of soccer playing positions. Midfielders will more likely be on the top of the centralities charts as they do a lot of work passing the ball from front to back and from back to front. If the team is initiating attacks, midfielders will rank high on the centralities, and if the team is taking a defensive stand, midfielders and back players will rank high on the centrality measures. Notable was that middle back and midfield seemed to always rank at the same height in the centrality charts depending on the situation the team is faced with. Front players seemed to rank low in all cases. The substitutions that took place in the time between the 2nd and 3rd time intervals had a significant effect at bringing the game's heat back. It was still most heated at the very beginning than at the end, but that is the natural case with all matches as players come energized and start getting exhausted with the passage of time, running around the field for 90 minutes. Noteworthy is that both teams had almost equivalent average clustering coefficients often ranging between 0.2 and 0.3. Chelsea's average clustering was always higher than Newcastle's, though. As for Newcastle's network evolution over time, it can be summed up as follows: The highest degree centralities, in order, were 9 to 6 to 4. The consistent decreasing in the value indicates the deteriorating of the network state over time. In the 1st time interval, the successful passes were 38 to 13 unsuccessful passes, in the 2nd they were 13 to 9, and in the 3rd, they were 10 to 14. Decreasing so badly to the point where the interceptions were higher than the successful passes. An evident drop in quality of performance. Key players were Lascelles, Targett, Schar, and sometimes Wood, who is the team's striker but was often found in the backfield assisting in defence. The 3 main key players are all defenders, which is a very obvious indication of the team's tactic and performance against the superior pressure applied by Chelsea. Although correct substitutions decisions were made to remove non-contributing players off the field, the changes did not save the network from falling apart. In general, the reason Chelsea has been able to posses the ball for most of the match as well as score is because of the strong compatibility of the team. It was a very starkly efficient network in contrast with the weak ties of Newcastle.

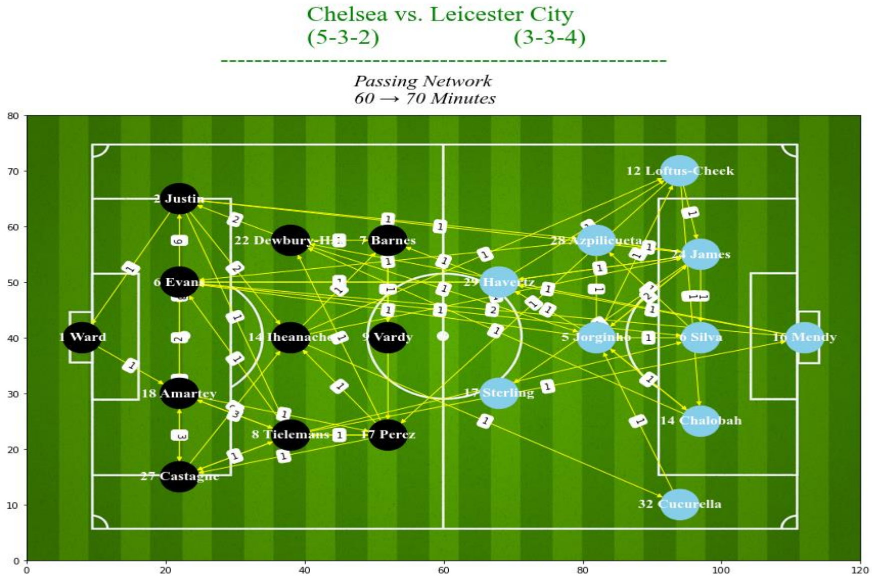
Data Analysis & Results – 2nd Match

Chelsea vs. Leicester City (August 2022)

For this match, we will apply the same approach of analysis of numbers, what they mean, what the order of the players on the charts indicates, and so on. However, as the thinking strategy has been made clear in the first match, we will sum up the analysis of the 2nd match by observing 2 critical time intervals only. The beginning of the match, so we can get a "feel" of the tactic of each team, and the time interval (60 – 70 Minutes) during which 2 goals have been scored.

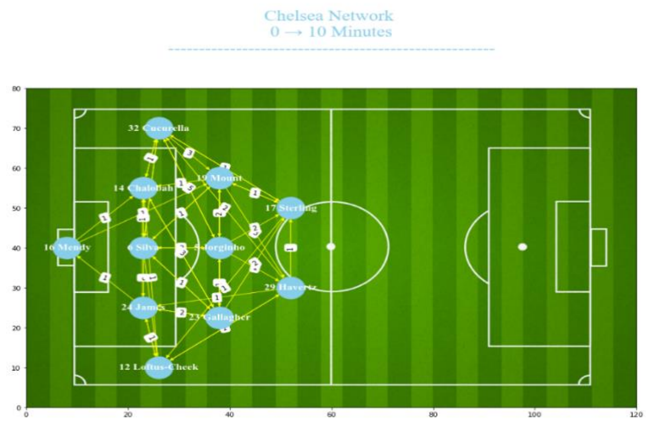


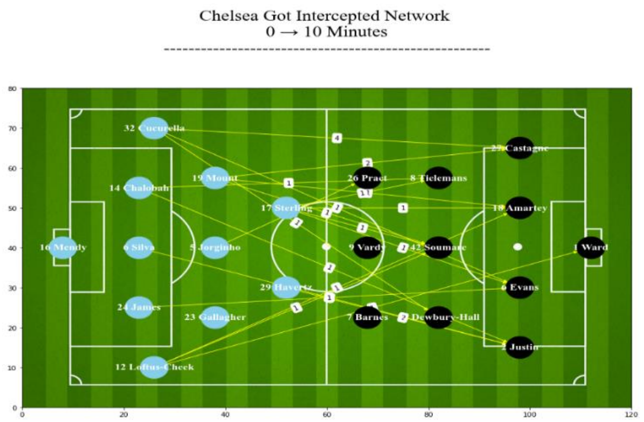
A very dense network filled with edges with big weights. As we have observed during the analysis of the 1st match, this intensity in passes will wear off as the time passes as players will start getting exhausted. We can observe that Leicester city's formation is Chelsea's from the 1st match, a dynamic formation able to operate through different initiatives from attacking to defending. This time around, Chelsea has placed 5 defenders at the back, 3 midfielders, and 2 on the front.



After some time of the start of the 2nd half, first thing we observe is that the players switched sides on the pitch. Second thing is that we can see the edges are naturally lesser now. Third is that one node is missing from Chelsea's team, and that is player Gallagher who has been eliminated from the game by getting a red card for aggressive "foul" play.

Chelsea's Performance (0 – 10 Minutes)






```
Player:  6 Silva  | Degree Centrality:  12
Player:  14 Chalobah  | Degree Centrality:  11
Player:  19 Mount  | Degree Centrality:  11
Player:  32 Cucurella  | Degree Centrality:  10
Player:  5 Jorginho  | Degree Centrality:  10
Player:  23 Gallagher  | Degree Centrality:  10
Player:  24 James  | Degree Centrality:  9
Player:  17 Sterling  | Degree Centrality:  8
Player:  12 Loftus-Cheek  | Degree Centrality:  7
Player:  29 Havertz  | Degree Centrality:  7
Player:  16 Mendy  | Degree Centrality:  3
```

```
Player:  24 James | Betweenness Centrality:  0.14002645502645503  | Degree:  9
Player:  14 Chalobah | Betweenness Centrality:  0.12874338624338624  | Degree:  11
Player:  19 Mount | Betweenness Centrality:  0.09462962962962962  | Degree:  11
Player:  6 Silva | Betweenness Centrality:  0.08593915343915344  | Degree:  12
Player:  32 Cucurella | Betweenness Centrality:  0.07937830687830688  | Degree:  10
Player:  23 Gallagher | Betweenness Centrality:  0.06965608465608465  | Degree:  10
Player:  12 Loftus-Cheek | Betweenness Centrality:  0.05555555555555556  | Degree:  7
Player:  29 Havertz | Betweenness Centrality:  0.048730158730158735  | Degree:  7
Player:  5 Jorginho | Betweenness Centrality:  0.036944444444444444  | Degree:  10
Player:  17 Sterling | Betweenness Centrality:  0.031031746031746032  | Degree:  8
Player:  16 Mendy | Betweenness Centrality:  0.007142857142857143  | Degree:  3
```

```
Player:  14 Chalobah  | Closeness Centrality:  0.7692307692307693  | Degree:  11
Player:  32 Cucurella  | Closeness Centrality:  0.6666666666666666  | Degree:  10
Player:  6 Silva  | Closeness Centrality:  0.6666666666666666  | Degree:  12
Player:  24 James  | Closeness Centrality:  0.6666666666666666  | Degree:  9
Player:  19 Mount  | Closeness Centrality:  0.6666666666666666  | Degree:  11
Player:  17 Sterling  | Closeness Centrality:  0.6666666666666666  | Degree:  8
Player:  12 Loftus-Cheek  | Closeness Centrality:  0.5882352941176471  | Degree:  7
Player:  5 Jorginho  | Closeness Centrality:  0.5882352941176471  | Degree:  10
Player:  23 Gallagher  | Closeness Centrality:  0.5882352941176471  | Degree:  10
Player:  29 Havertz  | Closeness Centrality:  0.5555555555555556  | Degree:  7
Player:  16 Mendy  | Closeness Centrality:  0.43478260869565216  | Degree:  3
```

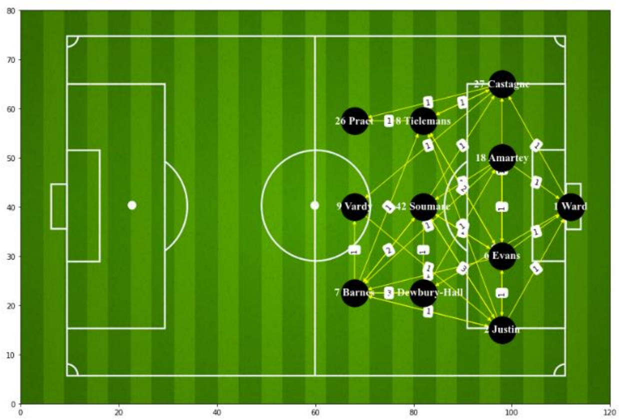
```
Player:  5 Jorginho | Clustering Coefficient  0.573170731707317 | Degree:  10
Player:  6 Silva | Clustering Coefficient  0.5245901639344263 | Degree:  12
Player:  23 Gallagher | Clustering Coefficient  0.5121951219512195 | Degree:  10
Player:  16 Mendy | Clustering Coefficient  0.5 | Degree:  3
Player:  32 Cucurella | Clustering Coefficient  0.47560975609756095 | Degree:  10
Player:  19 Mount | Clustering Coefficient  0.46153846153846156 | Degree:  11
Player:  17 Sterling | Clustering Coefficient  0.4423076923076923 | Degree:  8
Player:  14 Chalobah | Clustering Coefficient  0.4411764705882353 | Degree:  11
Player:  24 James | Clustering Coefficient  0.42424242424242425 | Degree:  9
Player:  29 Havertz | Clustering Coefficient  0.4 | Degree:  7
Player:  12 Loftus-Cheek | Clustering Coefficient  0.3684210526315789 | Degree:  7
```

Passing Network Density = 0.445454545454545
Global Average Clustering Coefficient = 0.46575017045444694
Interception Network Density = 0.04112554112554113
Sum of successful passes = 98
Sum of interceptions = 24
Interception Ratio = 24 / 98 = 0.24489795918367346

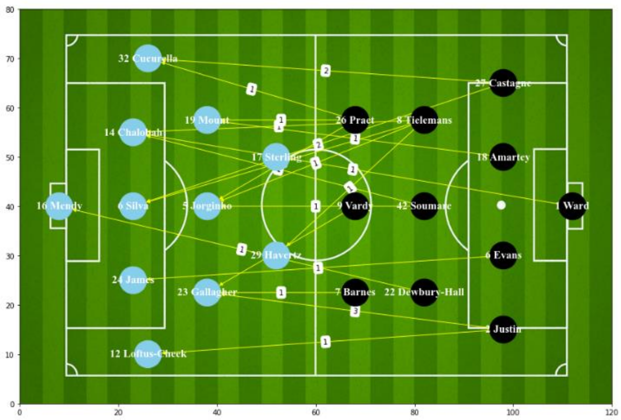
This was a very solid start for the team, almost every table of the measurements is balanced. Closeness centrality ranges from 0.4 to 0.7, evenly distributed. Same case goes for the clustering coefficient of each player (ranging from 0.3 to 0.5). Degree centralities are high and almost consistent throughout the whole team. Even Mendy, the goalkeeper, contributed. Key player is not very obviously found (although it could be Chalobah or Silva) and this is a very good indication because everyone in the team in contributing which means that, for the most part, the team can still handle themselves with the removal of one of them, meaning that the effectiveness of the network will not completely fall apart. From the heavy number of edges between backfield players, one could tell Chelsea was stalling to get a higher rate of ball possession early on in the game. The passing network density was 0.4 to 0.04 of the interception network density which is an excellent ratio. Total successful passes are 98 (almost 100 passes in only 10 minutes!) and 24 interceptions. From the tables here, we can't observe a directly proportional relationship between the centrality measures and that is because all the players are contributing in one way or another so it's harder to find contrasts, whereas it is easier to observe a proportionality case when some players aren't contributing because that means that the same players will be at the top of all the charts and the same players will be at the bottom. The overall clustering coefficient is 0.4 which is good enough and an indication that the team has strong ties. In fact, if it weren't for Mendy, it would be much higher, because, as can been seen from the graph, almost every node is connected to every other node by a pass. Another thing that the network graph illustrates is how much the midfielders and back fielders are passing the ball to Sterling and Havertz (the front players) to help initiate strikes on Leicester.

Leicester City's Performance (0 – 10 Minutes)

Leicester Network
0 → 10 Minutes



Leicester Got Intercepted Network
0 → 10 Minutes




```
Player:  6 Evans   | Degree Centrality:  11
Player:  7 Barnes   | Degree Centrality:  10
Player:  2 Justin   | Degree Centrality:  9
Player:  42 Soumare   | Degree Centrality:  9
Player:  27 Castagne   | Degree Centrality:  7
Player:  8 Tielemans   | Degree Centrality:  7
Player:  18 Amartey   | Degree Centrality:  6
Player:  1 Ward   | Degree Centrality:  5
Player:  22 Dewbury-Hall   | Degree Centrality:  5
Player:  9 Vardy   | Degree Centrality:  3
Player:  26 Praet   | Degree Centrality:  2
```

```
Player:  6 Evans | Betweenness Centrality:  0.16462962962962963  | Degree:  11
Player:  2 Justin | Betweenness Centrality:  0.14537037037037037  | Degree:  9
Player:  7 Barnes | Betweenness Centrality:  0.1290740740740741  | Degree:  10
Player:  8 Tielemans | Betweenness Centrality:  0.11185185185185187  | Degree:  7
Player:  27 Castagne | Betweenness Centrality:  0.09462962962962962  | Degree:  7
Player:  42 Soumare | Betweenness Centrality:  0.05962962962962963  | Degree:  9
Player:  22 Dewbury-Hall | Betweenness Centrality:  0.05925925925925926  | Degree:  5
Player:  1 Ward | Betweenness Centrality:  0.044814814814814814  | Degree:  5
Player:  9 Vardy | Betweenness Centrality:  0.03703703703703704  | Degree:  3
Player:  18 Amartey | Betweenness Centrality:  0.020370370370370372  | Degree:  6
Player:  26 Praet | Betweenness Centrality:  0.0  | Degree:  2
```

```
Player:  8 Tielemans  | Closeness Centrality:  0.5785714285714286  | Degree:  7
Player:  42 Soumare  | Closeness Centrality:  0.5785714285714286  | Degree:  9
Player:  7 Barnes  | Closeness Centrality:  0.5785714285714286  | Degree:  10
Player:  27 Castagne  | Closeness Centrality:  0.54  | Degree:  7
Player:  6 Evans  | Closeness Centrality:  0.54  | Degree:  11
Player:  2 Justin  | Closeness Centrality:  0.54  | Degree:  9
Player:  1 Ward  | Closeness Centrality:  0.50625  | Degree:  5
Player:  9 Vardy  | Closeness Centrality:  0.50625  | Degree:  3
Player:  26 Praet  | Closeness Centrality:  0.47619047619047616  | Degree:  2
Player:  18 Amartey  | Closeness Centrality:  0.45  | Degree:  6
Player:  22 Dewbury-Hall  | Closeness Centrality:  0.405  | Degree:  5
```

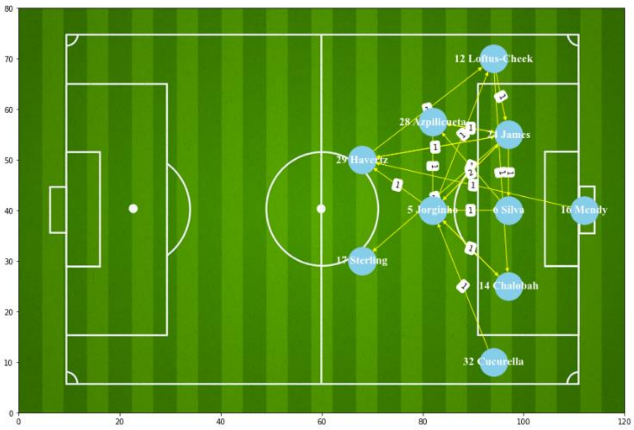
```
Player:  26 Praet | Clustering Coefficient  1.0 | Degree:  2
Player:  18 Amartey | Clustering Coefficient  0.5 | Degree:  6
Player:  42 Soumare | Clustering Coefficient  0.5 | Degree:  9
Player:  2 Justin | Clustering Coefficient  0.45454545454545453 | Degree:  9
Player:  22 Dewbury-Hall | Clustering Coefficient  0.4444444444444444 | Degree:  5
Player:  6 Evans | Clustering Coefficient  0.38235294117647056 | Degree:  11
Player:  7 Barnes | Clustering Coefficient  0.38095238095238093 | Degree:  10
Player:  8 Tielemans | Clustering Coefficient  0.3684210526315789 | Degree:  7
Player:  9 Vardy | Clustering Coefficient  0.3333333333333333 | Degree:  3
Player:  1 Ward | Clustering Coefficient  0.3 | Degree:  5
Player:  27 Castagne | Clustering Coefficient  0.225 | Degree:  7
```

Passing Network Density = 0.33636363636363636
Global Average Clustering Coefficient = 0.4444590551894238
Interception Network Density = 0.04112554112554113
Sum of successful passes = 51
Sum of interceptions = 24
Interception Ratio = 24 / 51 = 0.47058823529411764

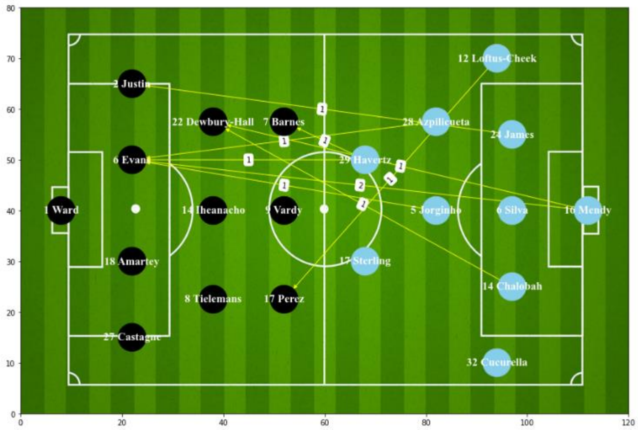
Leicester has been doing a very solid job too. All players of the squad are contributing, although Evans, Barnes, and Justin can be easily distinguished as the key players of the team. As for the closeness centrality, it is perfectly evenly distributed and balanced between the team, meaning that each player is close to and able to reach every other player; this is due to the squad's 4-3-3 compact formation. None of the players got 0 in any of the measures except for Praet in the betweenness centrality, which makes sense as he is a player placed at the edge of the formation, so it won't be often that he finds himself in the way of the ball passing from one player to another. Although it should be noted that player Barnes is at the edge too, yet he is found at the top of the centrality measures tables. The team has a total of 51 successful passes (half of Chelsea's successful passes) yet the same exact number of interceptions. Which easily points who's the winner of the 1st time interval network comparison. The interception rate is still within an acceptable range, though. From the interceptions graph, we can observe how Chelsea's Chalobah and Gallagher are the best 2 at intercepting balls from Leicester.

Chelsea’s Performance (60 – 70 Minutes)

Chelsea Network
60 → 70 Minutes



Chelsea Got Intercepted Network
60 → 70 Minutes




```
Player:  24 James   | Degree Centrality:  9
Player:  5 Jorginho   | Degree Centrality:  9
Player:  29 Havertz   | Degree Centrality:  5
Player:  12 Loftus-Cheek   | Degree Centrality:  4
Player:  28 Azpilicueta   | Degree Centrality:  4
Player:  14 Chalobah   | Degree Centrality:  3
Player:  6 Silva   | Degree Centrality:  3
Player:  16 Mendy   | Degree Centrality:  1
Player:  32 Cucurella   | Degree Centrality:  1
Player:  17 Sterling   | Degree Centrality:  1
```

```
Player:  24 James | Betweenness Centrality:  0.3472222222222222  | Degree:  9
Player:  5 Jorginho | Betweenness Centrality:  0.29166666666666663  | Degree:  9
Player:  29 Havertz | Betweenness Centrality:  0.10416666666666666  | Degree:  5
Player:  12 Loftus-Cheek | Betweenness Centrality:  0.027777777777777776  | Degree:  4
Player:  28 Azpilicueta | Betweenness Centrality:  0.013888888888888888  | Degree:  4
Player:  14 Chalobah | Betweenness Centrality:  0.006944444444444444  | Degree:  3
Player:  16 Mendy | Betweenness Centrality:  0.0  | Degree:  1
Player:  32 Cucurella | Betweenness Centrality:  0.0  | Degree:  1
Player:  6 Silva | Betweenness Centrality:  0.0  | Degree:  3
Player:  17 Sterling | Betweenness Centrality:  0.0  | Degree:  1
```

```
Player:  24 James  | Closeness Centrality:  0.5925925925925926  | Degree:  9
Player:  5 Jorginho  | Closeness Centrality:  0.5925925925925926  | Degree:  9
Player:  29 Havertz  | Closeness Centrality:  0.5470085470085471  | Degree:  5
Player:  12 Loftus-Cheek  | Closeness Centrality:  0.5079365079365079  | Degree:  4
Player:  14 Chalobah  | Closeness Centrality:  0.47407407407407404  | Degree:  3
Player:  17 Sterling  | Closeness Centrality:  0.42857142857142855  | Degree:  1
Player:  28 Azpilicueta  | Closeness Centrality:  0.4183006535947712  | Degree:  4
Player:  6 Silva  | Closeness Centrality:  0.3950617283950617  | Degree:  3
Player:  16 Mendy  | Closeness Centrality:  0.0  | Degree:  1
Player:  32 Cucurella  | Closeness Centrality:  0.0  | Degree:  1
```

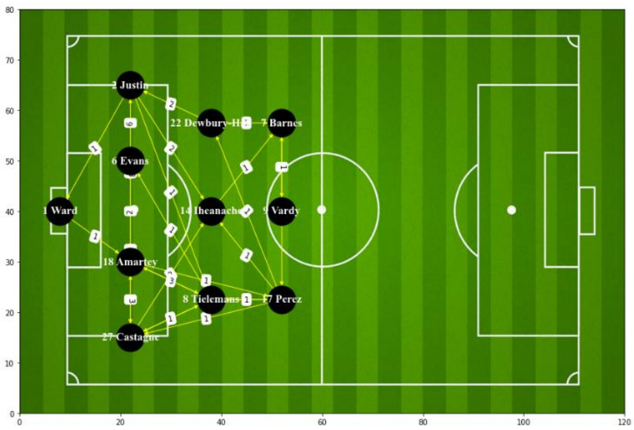
```
Player:  6 Silva | Clustering Coefficient  0.8333333333333334 | Degree:  3
Player:  28 Azpilicueta | Clustering Coefficient  0.7 | Degree:  4
Player:  12 Loftus-Cheek | Clustering Coefficient  0.5833333333333334 | Degree:  4
Player:  14 Chalobah | Clustering Coefficient  0.5 | Degree:  3
Player:  29 Havertz | Clustering Coefficient  0.3888888888888889 | Degree:  5
Player:  24 James | Clustering Coefficient  0.24242424242424243 | Degree:  9
Player:  5 Jorginho | Clustering Coefficient  0.23529411764705882 | Degree:  9
Player:  16 Mendy | Clustering Coefficient  0 | Degree:  1
Player:  32 Cucurella | Clustering Coefficient  0 | Degree:  1
Player:  17 Sterling | Clustering Coefficient  0 | Degree:  1
```

Passing Network Density = 0.2222222222222222
Global Average Clustering Coefficient = 0.3483273915626857
Interception Network Density = 0.02142857142857143
Sum of successful passes = 21
Sum of interceptions = 10
Interception Ratio = 10 / 21 = 0.47619047619047616

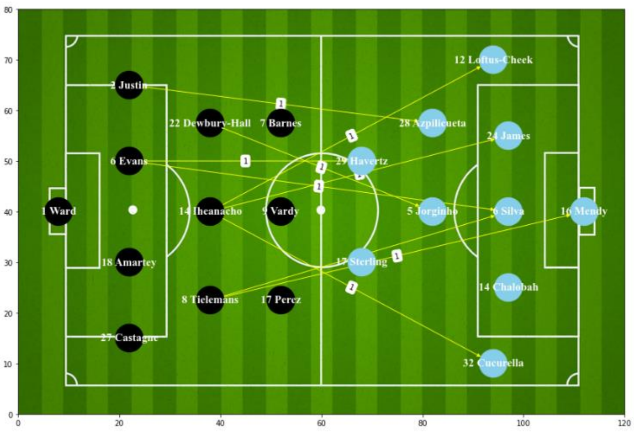
After the elimination of player Gallagher, we now follow only 10 players on Chelsea’s side of the pitch. The key player in this interval is James whose degree, betweenness, and closeness centralities are the highest among the entire team. As Gallagher had been playing in the position of a Centre Defensive Midfielder, he often intercepted the ball from Leicester and gave it back to Chelsea, so his loss from the team has a palpable effect most easily noticed in the total successful passes number that have dropped from about 100 to 21 passes now! Of course, there are other factors for the drop in the number of passes per 10 minutes, especially considering we’re in getting closer to the endgame, however the elimination of Gallagher has evidently affected the network intensity (lowered it). After him, Chelsea’s drive to take the ball back from Leicester has waned, so their ball possession percentage has dropped. Although they didn’t get to spend much time with the ball, during the few times they did, they initiated a successful attack during which player Sterling has scored a goal with an assist from James. And, as for Sterling himself, he actually ranked last in all the network measures except for closeness centrality as other players were able to reach him and pass him the ball often. The passing network density is 0.2, which is a decrease from the past interval, once again the elimination of Gallagher is a factor in that. The interception network density is 0.4 which is an increase from the past interval. This is a negative indicator. Once again, we can see that midfielders and back fielders are dominating the top of the measurements charts as they are the ones doing the most work. Finally, from the graph, we can observe that every player has interacted with the ball whether received it or passed it, no players were completely unengaged.

Leicester City’s Performance (60 – 70 Minutes)

Leicester Network
60 → 70 Minutes



Leicester Got Intercepted Network
60 → 70 Minutes




```
Player:  27 Castagne   | Degree Centrality:  8
Player:  18 Amartey   | Degree Centrality:  8
Player:  8 Tielemans   | Degree Centrality:  8
Player:  17 Perez   | Degree Centrality:  7
Player:  2 Justin   | Degree Centrality:  6
Player:  6 Evans   | Degree Centrality:  5
Player:  7 Barnes   | Degree Centrality:  5
Player:  14 Iheanacho   | Degree Centrality:  4
Player:  22 Dewbury-Hall   | Degree Centrality:  3
Player:  1 Ward   | Degree Centrality:  2
Player:  9 Vardy   | Degree Centrality:  2
```

```
Player:  17 Perez | Betweenness Centrality:  0.387037037037037   | Degree:  7
Player:  7 Barnes | Betweenness Centrality:  0.3037037037037037   | Degree:  5
Player:  2 Justin | Betweenness Centrality:  0.1907407407407407   | Degree:  6
Player:  18 Amartey | Betweenness Centrality:  0.1537037037037037   | Degree:  8
Player:  27 Castagne | Betweenness Centrality:  0.12222222222222223   | Degree:  8
Player:  14 Iheanacho | Betweenness Centrality:  0.12222222222222223   | Degree:  4
Player:  22 Dewbury-Hall | Betweenness Centrality:  0.12222222222222223   | Degree:  3
Player:  8 Tielemans | Betweenness Centrality:  0.09814814814814814   | Degree:  8
Player:  6 Evans | Betweenness Centrality:  0.07777777777777778   | Degree:  5
Player:  1 Ward | Betweenness Centrality:  0.0   | Degree:  2
Player:  9 Vardy | Betweenness Centrality:  0.0   | Degree:  2
```

```
Player:  8 Tielemans   | Closeness Centrality:  0.5555555555555556   | Degree:  8
Player:  17 Perez   | Closeness Centrality:  0.5555555555555556   | Degree:  7
Player:  27 Castagne   | Closeness Centrality:  0.5263157894736842   | Degree:  8
Player:  14 Iheanacho   | Closeness Centrality:  0.5263157894736842   | Degree:  4
Player:  18 Amartey   | Closeness Centrality:  0.47619047619047616   | Degree:  8
Player:  7 Barnes   | Closeness Centrality:  0.45454545454545453   | Degree:  5
Player:  6 Evans   | Closeness Centrality:  0.43478260869565216   | Degree:  5
Player:  2 Justin   | Closeness Centrality:  0.4166666666666667   | Degree:  6
Player:  22 Dewbury-Hall   | Closeness Centrality:  0.38461538461538464   | Degree:  3
Player:  1 Ward   | Closeness Centrality:  0.3225806451612903   | Degree:  2
Player:  9 Vardy   | Closeness Centrality:  0.3225806451612903   | Degree:  2
```

```
Player:  6 Evans | Clustering Coefficient  0.6666666666666666 | Degree:  5
Player:  1 Ward | Clustering Coefficient  0.5 | Degree:  2
Player:  8 Tielemans | Clustering Coefficient  0.5 | Degree:  8
Player:  18 Amartey | Clustering Coefficient  0.46153846153846156 | Degree:  8
Player:  27 Castagne | Clustering Coefficient  0.46 | Degree:  8
Player:  17 Perez | Clustering Coefficient  0.325 | Degree:  7
Player:  2 Justin | Clustering Coefficient  0.16666666666666666 | Degree:  6
Player:  14 Iheanacho | Clustering Coefficient  0.16666666666666666 | Degree:  4
Player:  22 Dewbury-Hall | Clustering Coefficient  0.16666666666666666 | Degree:  3
Player:  7 Barnes | Clustering Coefficient  0.1111111111111111 | Degree:  5
Player:  9 Vardy | Clustering Coefficient  0 | Degree:  2
```

Passing Network Density = 0.2636363636363636
Global Average Clustering Coefficient = 0.32039238539238535
Interception Network Density = 0.02142857142857143
Sum of successful passes = 49
Sum of interceptions = 9
Interception Ratio = 9 / 49 = 0.1836734693877551

Although the number of successful passes decreased a little, the interception ratio is excellent. Leicester City’s squad may not have done lots of passes, but whatever few passes they made, they had even less interceptions. Also, 49 successful passes is more than double what Chelsea was able to make. So, the ball possession percentage was higher for Leicester. From the measurement tables, one cannot easily identify who the key player is, but it is notable that players from every position on the field are on the top of the charts which means the whole team is making an effort and contributing to the game. Players with the highest degree centralities seem to be back fielders which means that the team was often passing the ball to the back and stalling to increase possession to build up heat to score, and score they did with Vardy’s assist to Barnes. The high possession percentage is also because Leicester has an extra man advantage on Chelsea, and the fact that Gallagher, the most aggressive interceptor from Chelsea is not absent from the field. The global clustering coefficient is 0.3, which is the same as Chelsea’s during this time interval which means that both teams had ties of equal strength between their players. Seems as though Leicester is a true match for Chelsea. The interception network density being 10 times lesser than the passing network density shows how the team is trying to even the score out (2-1) and not lose to Chelsea. Leicester proved to be a competitive team all the way to the end, in fact, the number of successful passes between Chelsea’s players will continue to decrease while Leicester decreases, but even despite all that improvement of performance, Leicester were not able to score a 2nd goal.

Finally …

To sum up the evolution of Chelsea's network over time, we can observe the change in the highest degree centralities in both time intervals to give us a general indication of the state of the network as time passes. Highest degree centrality was 12 then it became 9. Not a very bad drop, but a drop, nonetheless. As for the average clustering coefficient, it was 0.4 and became 0.3 which indicates the team has been able to keep the strength of their ties relatively constant. In the 1st time interval, it was hard to identify the key players of the match, but in the 2nd, it was clearly James, who also gave the 2nd goal's assist to Sterling. Sterling, although the scorer of the 2 winning goals of Chelsea, was often found at the bottom of the charts. This makes sense as his position as a front fielder is mainly initiating attacks on the opposite squad, not passing the ball back into his network. From the tables, we can see the front fielder Havertz has ranked higher than Sterling as he had more engagement with the ball, but his balls were often intercepted by Leicester's defenders. Finally, although the squad is a high functioning one that did not completely shatter as a network when one node (Gallagher) was removed, Gallagher's absence shifted the game to Leicester's advantage. It can be reasoned why Gallagher has had such a faint but constant effect on leaving the network because if you observe the charts for the 2nd match, you'll find him ranking at the top of most centrality measures. To sum up the evolution of Leicester City's network over time, their highest degree centrality in the 1st time interval was 11 then 8 in the 2nd. The decrease is due to the adrenaline rush at the beginning of the game which had every player of the squad active in comparison with being more than halfway into the game. A better indication in this case would be the number of successful passes and interceptions over time. The number of successful passes was 51 then became 49, which shows that the squad have been able to maintain consistency in passing frequency even that long into the game. The interesting change is in the number of interceptions, though, as it was 24 then became 9, which has the absence of Gallagher from Chelsea written all over it. It also means that no player in Chelsea could make up for Gallagher's role in the squad and what he contributed to the network. Leicester performed a competitive game, proving themselves a match for Chelsea, perhaps even scoring 2 goals to even the score out if the match lasted any longer as they were pressing very hard in the last minutes. An overall more "dramatic" match than the 1st one, with start changes. Finally, this constant attack from Leicester's front fielders with the aid of midfielders explains the reason why Chelsea chose the formation 2-3-5, as they wanted to attack but also knew that they needed to protect themselves.

Comparison of Chelsea's Performance Against Different Squads

Chelsea's playing tactic becomes quite obvious now. They study the team they are going against and form themselves on the field accordingly. In the 1st match, the seem to have not regarded Newcastle United as a threat, which lead them to standing in a more relaxed formation of 3-3-4, allowing for ease of dynamic switching from defence to attack. Whereas in the 2nd match, the were more conservative as they clearly viewed Leicester City as a competitive squad that could possibly change the outcome of the game if they weren't careful, which had them forming a 2-3-5, with some midfielder assisting in both attacking and defence at once. The squad used generally the same players, we can also note that they did not reuse the ones that were substituted in the 1st match for the 2nd match except for Mount, who was eventually substituted again. Overall, during both matches, Chelsea has been able to hold itself together as a network, it has highs and lows, but the average is constant and consistent. They displayed the same skill (except for intercepting), same strength of ties, chemistry, and players' contribution. They did a better performance in the 1st match due to the "weakness" of Newcastle in comparison to Leicester City.

Conclusion

Network Characteristics for a Successful Squad Performance

We now understand that the formation type is not always the same for a successful squad performance as it also depends on adapting your strategy to the opposite team. However, generally, the network characteristics are the same. Successful means being able to defend yourself against attacks and initiate ones yourself when the opportunity arises, it means always having an evenly distributed closeness centrality, and more than one player with a big degree centrality. It means every node would have a value of betweenness centrality, even better if it were evenly distributed among all nodes such that all of them would have to engage with the ball to form an efficient and well-connected network utilizing every node it is comprised of. It also means having clustering coefficients for every player to represent an overall network comprised of numerous strong ties. And, most importantly, having a low ratio of interceptions to passes.

As a final note, we conclude that network analysis surely is a beneficial way to gain some deep insight on the performance of each team, although it is quite inefficient and time-consuming in terms of collecting data. For example, collecting the passing data of 45 minutes of play took 4 hours and inputting collected data into Excel's matrix took 45 minutes for each 10 minutes! Without a doubt, the utilization of APIs is essential if such study is to be conducted regularly or simply the gained insight may not be worth the effort.

Team Members' Contributions

[redacted]	1. 1st Match data collection 2. Code for both matches 3. Authoring the project report 4. Reading all resources provided by Anas
[redacted]	1. 2nd Match data collection 2. Commentary and annotations of the code 3. Authoring the project report 4. Collecting resources for reference

Reflection on the Project

This may not be objectively related to the topic we've handled, but we thought to share some insight on the experience of this project, beginning with being paired together without any previous acquaintanceship, all the way to the day of the report submission at the end of the semester. Although it would've been much more convenient to get to choose our own project partners –people with which we find compatibility in the working style and familiarity with character–, getting that option taken away from us was as inconvenient as it was character-building. Getting the opportunity to diversify our colleagues like this really does push you out of your comfort zone, but after the haze of the event is over, you'll find yourself seeing all the new things you got to learn from the new people you now know, people whom you never expected to have to work with, you'll find yourself counting the things you have in common which evokes a sense of community. It gets you thinking about all the moments you passed by strangers thinking how intimidating it must be talking or getting to know them, when, in fact, they're just as much human as you are, with all the insecurities and the overthinking and the big plans that come with it. Not only that, but it was simply fun getting in contact with different cultures and languages. We may have –and that's likely the case– continued the rest of our university years never crossing one another's paths, never even paying mind to it, but we're glad it happened. We now see the benefit this team-assigning style has, sculpting a resilient and situation-adjusting character by exposing us to the world, whomever it may bring, and asking of us to deal with it. This is priceless education. We both were in this together and we both intended to score the highest grade possible. Knowing communication is key, right away we started setting up plans for contact and syncing our free times to work on the many stages of this project. No matter how hard, long, or frustrating it got sometimes, we ended up feeling truly confident in our Python coding and network analysis skills. Not to mention the deep sense of accomplishment. The provided resources were indispensable, the research about all the little technicalities was imperative, and all the advice given to us by the professor were invaluable. There is a quote that says "Teach me and I forget. Show me and I remember. Involve me and I understand.", and this project has been the precise application of that, through and through.

Thank you for every part of this assignment.

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